MEC22
MYOELECTRIC CONTROLS SYMPOSIUM

Conference Program
August 9-11, 2022
Fredericton, New Brunswick, Canada

EST. 1785 UNB UNIVERSITY OF NEW BRUNSWICK | Institute of Biomedical Engineering

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Note: This document contains abstract submissions only. The full conference proceedings are available on the MEC conference website.

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Welcome to MEC22

On behalf of the organizing committee and the Institute of Biomedical Engineering staff at the University of New Brunswick, we would like to welcome you to MEC22. We are so pleased to see you after five long years! The pandemic has presented many challenges and uncertainties over the last two years, making our decision about the timing and format of hosting MEC difficult. We took a leap of faith in offering a hybrid event this year and are thrilled to welcome all of you in person and online for this year's conference. We hope you all agree that the program, the venue, the opportunities to reconnect and network with international colleagues, and the warm hospitality of our staff and city make the frustrations and challenges of travelling here, at this time, worthwhile.

This year's keynote speakers will highlight many advances in research and technology in issues pertaining to upper limb prosthetics.

- **Prof. Max Ortiz Catalán**, Ph.D., is the Founder and Director of the Center for Bionics and Pain Research and the Professor of Bionics at Chalmers University of Technology, Sweden. His research includes bioelectric signals, neuromuscular interfaces, sensory feedback, osseointegration, and the treatment of phantom limb pain.

- **Matthew Ames**, BE (Env), MBA (Tech Mgt), was 39 years old when what started as a sore throat resulted in the loss of all four of his limbs (both above elbow above knee). Matthew has a unique mix of professional and personal experience. With a grounding of almost 20 years in the energy and resources industry, he has found innovative ways to apply his knowledge for maximizing prosthetic use to achieve his goals.

- **Dr. Arun Jayaraman** is a Professor of Physical Medicine & Rehabilitation, Physical Therapy & Human Movement Sciences, and Medical Social Sciences at Northwestern University's Medical School in Chicago. His work primarily focuses on outcomes research in prosthetics, orthotics, rehabilitation robotics, and other assistive and adaptive technologies to treat physical disability.

We hope you will join us for the conference dinner and kitchen-party entertainment on Wednesday, August 10th. Social events are an important part of MEC, as they allow time for informal networking and discussion of the ' 'day's events, while experiencing some of ' 'Fredericton's warm hospitality.

Once again, welcome to MEC22. Please don't hesitate to ask questions to any of our staff members.

Wendy Hill Jon Sensinger

Co-Chairs MEC22

MEC22 Organizing Committee

Janelle Aikens

Katie Campbell

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Financial Support

The Institute of Biomedical Engineering and the MEC22 Organizing Committee gratefully recognize the following organizations for their contributions to the symposium

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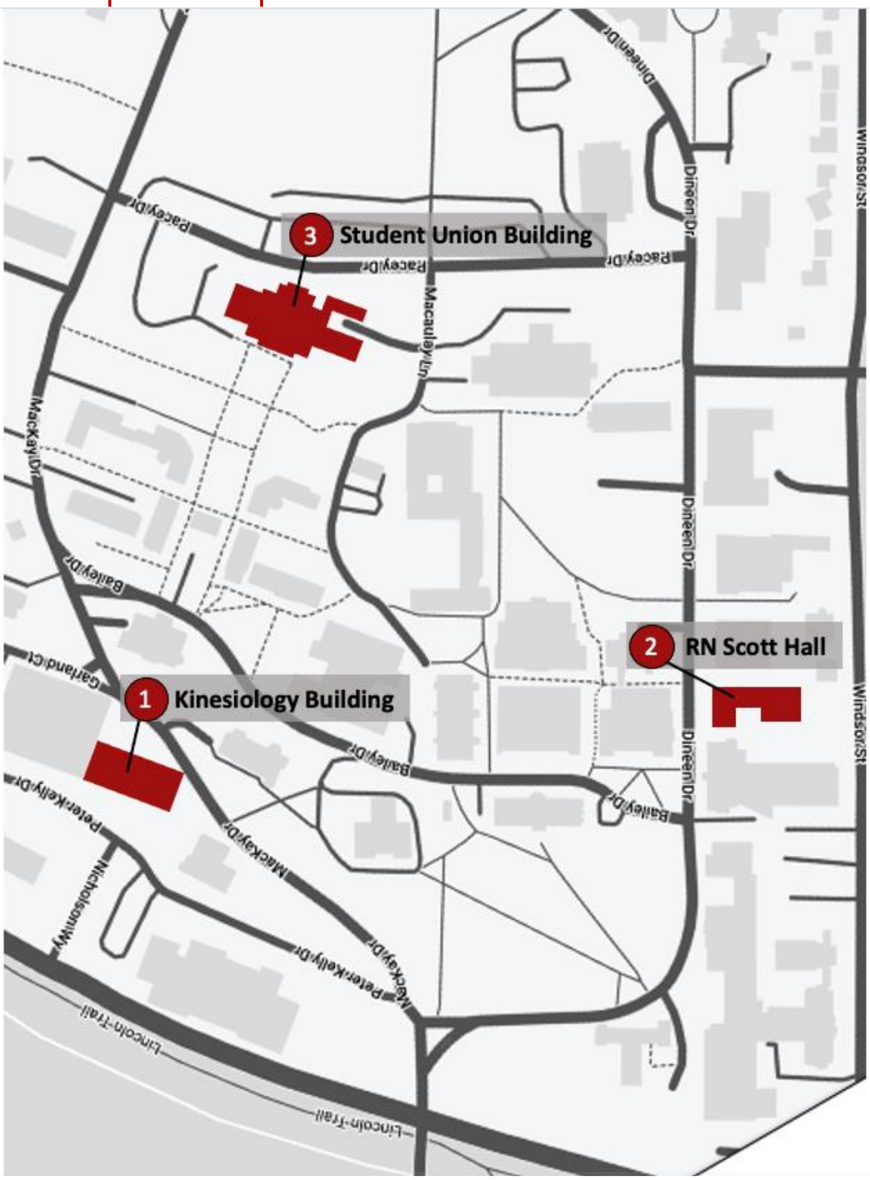
Campus Map



1 Kinesiology Building: 90 Mackay Drive (Pre-conference workshops - August 8th)

TASKA Workshop 8:30 AM-12:30 PM Kin building room 214

Adaptive Equipment for Bilateral Upper Limb Loss workshop 9 AM-11 AM Kin building room 201. **Note:** Please use the upper entrance on Mackay Drive.

2 RN Scott Hall (IBME) 25 Dineen Drive (Pre-conference workshops - August 8th)

Phantom Limb Pain pre-conference workshop 1 PM–5 PM (coffee break included)

3 UNB Student Union Building (SUB) 21 Pacey Drive (MEC22 Conference August 9th-11th)

The MEC22 Conference, Exhibitor Space, and Banquet will be hosted at the UNB Student Union Building Ballroom and Atrium

Conference Schedule

TIMES	Tuesday, August 9th	Wednesday, August 10th
7:30 AM	Registration Desk Opens (SUB Bottom Floor)	Registration Desk Opens (SUB Bottom Floor)
8:00–8:30 AM	Buffet Breakfast (SUB Ballroom)	Buffet Breakfast (SUB Ballroom) Vendor Workshop Point Designs (SUB Ballroom)
8:30-9:00 AM	Vendor Workshop Ossur (SUB Ballroom)	Vendor Workshop Aether Biomedical (SUB Ballroom)
9:00–9:15 AM	Welcome Address	Morning Comments
9:15–10:15 AM	Keynote - Max Ortiz Catalán (SUB Ballroom)	Keynote - Matthew Ames (SUB Ballroom)
10:15–10:45 AM	Nutrition Break/Vendor Displays (SUB Bottom Floor)	Nutrition Break/Vendor Displays (SUB Bottom Floor)
10:45AM-12:00 PM	Session A - Paper Presentations (5 papers) (SUB Ballroom)	Session C - Paper Presentations (5 papers) (SUB Ballroom)
12:00-1:00 PM	Lunch Vendor Displays (SUB Bottom Floor)	Lunch Vendor Displays (SUB Bottom Floor)
1:00-2:00 PM	Perspective Talk - Jacqueline Hebert (SUB Ballroom) Perspective Talk - Ed Iversen (SUB Ballroom)	Perspective Talk - Dick Plettenburg (SUB Ballroom) Perspective Talk - Blair Lock (SUB Ballroom)
2:00-3:15 PM	Fast-Track Poster Presenters (SUB Ballroom) In-Person Poster Session (SUB Bottom Floor) Nutrition Break/Vendor Displays (SUB Bottom Floor)	Virtual Poster Session (Gathertown) Nutrition Break/Vendor Displays (SUB Bottom Floor)
3:15-4:30 PM	Session B - Paper Presentations (5 papers) (SUB Ballroom)	Session D - Paper Presentations (5 papers) (SUB Ballroom)
4:30-4:45 PM	End of Day Comments	End of Day Comments

6:30pm - MEC Dinner & Student Award
(SUB Bottom Floor)

TIMES	Thursday, August 11th	
7:30 AM	Registration Desk Opens (SUB Bottom Floor)	
8:00–8:30 AM	Buffet Breakfast (SUB Ballroom)	Vendor Workshop Naked Prosthetics (SUB Ballroom)
8:30-9:00 AM	Vendor Workshop Aether Biomedical (SUB Ballroom)	
9:00-9:15 AM	Morning Comments	
9:15-10:15 AM	Keynote - Dr. Arun Jayaraman (SUB Ballroom)	
10:15-10:45 AM	Nutrition Break/Vendor Displays (SUB Bottom Floor)	
10:45-12:00 PM	Session E - Paper Presentations (5 papers) (SUB Ballroom)	
12:00-1:00 PM	Lunch Vendor Displays (SUB Bottom Floor)	
1:00-1:30 PM	Perspective Talk - Patrick Pilarski (SUB Ballroom)	
1:30 - 2:15 PM	Session F - Paper Presentations (3 papers) (SUB Ballroom)	
2:15 - 2:45 PM	Nutrition Break/Vendor Displays (SUB Bottom Floor)	
2:45 - 3:45 PM	Session G - Paper Presentations (4 papers) (SUB Ballroom)	
3:45 - 4:15 PM	Closing Remarks	

Fast Track Poster Sessions

There will be two poster sessions: in-person on Tuesday, August 9th at 2:00 PM and a virtual session on Wednesday, August 10th at 2:00 PM.

These sessions will occur during the afternoon breaks on both days. The in-person poster session will begin with each presenter having one minute at the podium to describe their work. Presenters will then proceed to their posters, where they will be available to answer questions until 3:15 PM.

The list of posters and presenters can be found on the following program pages.

Student Paper Competition

All students who have indicated that they wish to participate in the student paper competition will have their work judged to determine the quality of their presentation and the contribution of their work to the field. Judges have been chosen to ensure a fair assessment of the technical and clinical relevance of each student's work. The top presenter will be awarded a cash prize During the Banquet Dinner on Wednesday evening.

Notice Regarding Audio/Visual Recording and Photography of Event

The University of New Brunswick Institute of Biomedical Engineering (UNB IBME) will be live streaming presentations as part of our virtual conference platform. It may elect to photograph people and events during the MEC22 workshops, symposium, and networking events from August 8th to 11th, 2022. By attending MEC22, you agree to permit UNB IBME to use your likeness in these photos in the promotion of the conference. The Release checked off when registering indicated that you agree that UNB IBME shall be the copyright owner of the photographs and may use and publish these photographs. UNB IBME is released from any and all claims and causes of action that you may have now or in the future based upon or in connection with photographs and UNB IBME's use of the photographs in any manner. All rights granted to UNB IBME by you in the Release are irrevocable and perpetual. You waive all rights to any equitable relief in connection with the Release and the subject matter of the Release.

ABC and OPC Continuing Education Credits

MEC22 attendees present from August 9th to 11th will be eligible to receive continuing education credits from *The American Board for Certification in Orthotics, Prosthetics, and Pedorthics* and *Orthotics Prosthetics Canada*. For each morning and afternoon session, a sign-up sheet will be at the Registration Desk. A Certificate of Attendance from IBME will be mailed to delegates in the fall.

Social Events

Welcome walk across the Bill Thorpe Walking Bridge to Picaroons Roundhouse & 540 North

Monday, August 8th, 6:30 PM-9 PM

Everyone available is welcome to join us. We will meet at the Beaverbrook Art Gallery (703 Queen Street, across from the legislature and steps away from the Hilton and Crowne Plaza). We'll plan to cross the Walking Bridge to Picaroons for an informal gathering, depending on weather and numbers. The Picaroons Roundhouse and 540 North feature New Brunswick-craft beer, cider, spirits and wine from producers across the province and an elevated casual dining menu. Come meet new friends and catch up with old ones! Delegates are responsible for the purchase of their own food and drinks.

Banquet Dinner & Maritime Kitchen Party

SUB cafeteria

Wednesday, August 10th, 6:30 PM-11 PM

This year's banquet will be a fun, casual Maritime summer gathering.
Entertainment will be provided by the Montgomery Street Band, a New-Brunswick string band, followed by a music circle where we encourage everyone with musical talent (or at least enthusiasm) to join in the fun.
The banquet dinner is included in your general registration. To purchase a guest ticket ($80), please contact Annette Wetmore (awetmore@unb.ca)

Keynote Speakers and Perspective Talks

Tuesday, August 9th

Keynote Address 9:15 AM-10:15 AM

Max Ortiz Catalán, PhD.
Phantom Limb Pain (PLP): potential origin and treatment.
Technology has the potential to allow patients to reintegrate into society after traumatic events leading to amputations or motor impairments. In addition to the functional challenges, these patients often develop chronic neuropathic pain that further hinders their quality of life. Research and clinical innovations on the treatment of post-amputation pain have increased in the past decade. A growing interest on post-amputation pain, particularly in phantom limb pain (PLP), has resulted in new treatments, basic research findings, and theories that have increased our understanding of this condition. In this lecture, Prof. Ortiz Catalán will provide an overview of the field and discuss his recent hypothesis for the neurogenesis of PLP (Ortiz-Catalán, Frontiers in Neurology, 2018), along with a novel theoretical framework for further understanding the condition and improving its treatment.

Prof. Max Ortiz Catalán, Ph.D., is the Founder and Director of the Center for Bionics and Pain Research (@CBPR.se) and the Professor of Bionics at Chalmers University of Technology, Sweden. He has received several honors for his work, notably the "Swedish Embedded Award" by the Swedish Electronic Association in 2018, the "Brian & Joyce Blatchford Award" by ISPO in 2017, the "Delsys Prize" by Delsys in 2016, and the "European Youth Award" by the European Council in 2014. His research includes bioelectric signals acquisition electronics (analog and digital); bioelectric signal processing and machine learning algorithms for decoding motor volition and control; neuromuscular interfaces; neurostimulation for sensory feedback; bone-anchored prostheses and osseointegration; and virtual and augmented reality for neuromuscular rehabilitation and the treatment of phantom limb pain.

Perspective Talks 1–2 PM

Jaqueline Hebert
Is a sensory-motor prosthesis achievable?
There have been notable advances in powered upper-limb prostheses, driven by new surgical procedures and technological developments. Surgeries such as targeted muscle reinnervation, in parallel with advanced prosthetic control, training algorithms and technology device development, have led to multifunctional prostheses with greater potential to restore arm function than ever before. Nevertheless, motor output is just one component of upper limb function. The hand is a sensory organ; loss of sensation leads to a disconnect from the brain to the action of the device. No matter how sophisticated the tool, it cannot entirely be accepted as a functional limb without relevant closed-loop feedback. The introduction of a clinical program of targeted reinnervation at our center stimulated several lines of collaborative interdisciplinary research, including myoelectric control training, sensory feedback, and outcome assessment. This talk will review our lab's progress in these areas and discuss the barriers

and possible facilitators to changing clinical practice through sensory-motor research advances.

Edwin K. Iversen

Utilius, Fortius, Levius- The Recent Evolution of Upper-Limb Prosthetics from a Design ' 'Engineer's Perspective

Overview

As the Vice President of Research and Development for Motion Control, a Fillauer company, Ed Iversen has had a unique view of industry development over the last 20 years. The purpose of this perspective talk is to present some observations concerning the evolution of the design of upper-limb prosthetic components from a design engineer's perspective.

Introduction

Through his work in design engineering and device evaluation, and regular contact and collaboration with individuals dealing with upper-limb loss for over two decades, prosthetic design engineer Ed Iversen has learned that for an upper-limb prosthetic device to be desirable and most effective for users, it must be functional, reliable, lightweight, quiet, and aesthetically pleasing. Each of these areas will be addressed during the presentation.

Functional

Over the last 20 years, upper-limb devices have greatly enhanced functionality. Improvement has been made to wrist options, device compliance, hand function, and force feedback. Multiple terminal device options have also been developed to aid in everything from playing the violin, to farming and there are many other activity specific devices. There is still room to improve in each of these areas, such as greater acceptance of wrist flexion, and improved implementation of force feedback systems.

Reliable

Early devices failed often, were difficult and expensive to repair, and were often abandoned by the user in frustration. Today the design of prosthetic systems has become more reliable, using stronger materials, better design, and safety breakaway systems. Water and dust resistance has always been critical for device reliability, yet surprisingly few systems today have that essential feature. Water is a common part of daily life and upper-limb systems must be designed to handle wet environments.

Lightweight

Weight is a critical factor in upper-limb design. Designers of upper-limb prosthetic systems need to place a greater focus on creating much lighter systems than currently exist to aid upper-limb patients in working more easily with their devices.

Quiet

Prosthetic systems must be quiet to avoid drawing attention or bothering those around the individual using the device. There are four main ways to reduce noise in electromechanical systems: reduction, isolation, dissipation, and encapsulation. These techniques have been used in various ways and to various levels of success in current industry devices.

The '"Cool' Factor

Prosthesis users either want their devices to be as inconspicuous as possible, or they want them to make a visual statement. Both aesthetic approaches have made great strides over the last 20 years. In general, the same design principles are important in prosthetic systems as they are in other consumer products such as cars, clothing, and furniture. Form should follow function and lines and/or curves should be continuous. Watching industry trends as new system designs are imagined is imperative.

Conclusion

The future of upper-limb prosthetics lies in systems that are more functional, more reliable, lighter weight, quieter, and 'cooler' looking. New systems coming to the market should combine the benefits of body-powered and externally powered systems. The future of upper-limb design is full of exciting possibilities. It is a pleasure to be a part of the progress.

Wednesday, August 10th

Virtual Keynote Address 9:15 AM-10:15 AM

Matthew Ames, BE (Env), MBA (Tech Mgt)
Pushing the limits: Achieving Amazing Outcomes for a Quad Amputee
Following bilateral trans-humoral and bilateral transfemoral amputations in 2012, Matthew will highlight the opportunities and challenges he has faced in achieving outcomes to live his best life. As a user of prosthetics on all four limbs, 24 hours a day, he will share his unique perspective on prosthetics, including osseointegration, targeted muscle reinnervation and pattern recognition.

Matthew Ames was 39 years old when what started as a sore throat resulted in the loss of all four of his limbs (both above elbow above knee). Matthew has a unique mix of professional and personal experience. With a grounding of almost 20 years in the energy and resources industry, he has found innovative ways to apply his knowledge for maximising prosthetic use to achieve his goals. Matthew is involved in a variety of endeavours, serving on boards and steering committees for several organisations, including Bionics Queensland, State and Federal Governments and not-for-profit organisations.

Perspective talks 1 PM-2 PM

Dick Plettenburg (virtual)
Upper limb prostheses – future perspectives for body-powered prostheses
Body-powered upper-limb prostheses (BPP have many advantages over EMG-controlled, electrically actuated ones (myo's), including mass, reliability, and proprioceptive feedback. Despite these advantages, BPP are rejected as often as myo's. Reasons mentioned include mass (despite being lower than myo's), and comfort (especially of the harness). In addition, recent research has shown the operating forces of BPP being too high. As a result, the main advantage of BPP– feedback – is overshadowed, and the high operating forces negatively influence the comfort. Current research at the Delft Institute of Prosthetics and Orthotics aims at improving the performance of upper-limb prostheses. First results show a promising future for prostheses controlled and/or powered by body movements, while satisfying the basic requirements for upper limb prostheses.

Blair Lock
CTRL-Shift-Data: The fundamental change in myoelectric controls research and development
It is no secret that many academic and commercial research studies involving upper limb (UL) myoelectric controls are plagued by low subject count. Among other factors, there simply is not a large subject pool, subjects are geographically widespread, and studies are expensive and time-consuming to conduct. It has often been easier for researchers to have intact-limb subjects as substitutes to approximate the myoelectric control of individuals with UL difference. Furthermore, studies that do include individuals with UL difference are usually confined to a research laboratory/clinic and limited clinical assessments are used to generate outcomes – commonly users are even wearing a prosthesis prototype that is not representative of their real-world or long-term

functional use. As such, data is only somewhat representative, at best, to actual, at-home functional use and performance when wearing a myoelectric 'signals' -controlled prosthesis.

In addition, candid conversations in the field have historically exposed hesitancy in collecting functional data in a different way – that is, against using the microcomputers embedded in the devices to record usage counts and frequency while being worn "at-home". For some clinicians, there have been fears this data could be used to counteract reimbursement justification. For some manufacturers, the data would be too rudimentary with simple actuation counts or power cycles and not highlight device capabilities, or provide enough functional, clinical insight.
Fast-forward to today's growing acceptance of Connected Heath Technologies and we see a beneficial change for our field of study. The world around us has grown into cloud connectivity for wearable devices including "Big Data" storage and AI computing. Data is not only consumed by users, but also expected and welcomed. Many are even motivated by the self- or peer-competitive presentations of their data story. This familiarity and comfort of data consumption has led to improved connected health systems in many fields and is further bolstered where practitioners are able to better monitor and assess real-world data of their clients. The effects of Covid have further accelerated the use and comfort of virtual- or tele-rehabilitation. We are at the forefront of riding this change for the benefit of "data" being acquired for UL myoelectric 'controls' R&D.

Using the Coapt pattern recognition controller system as an example, we can start to see how fundamental "data" collection will significantly change in our field. The system's hardware is uniquely positioned to record rich user intent and activity, correlated with prosthesis actions. This real-world, real-time correlation of data embodies the gold standard of what UL controls research has been seeking to uncover for decades, and the data is becoming available at a scale not possible before. In one recent study, we collected more fully compliant and protected data in two weeks than we had cumulatively collected in the decade before. At the time of submission, more than 60 Coapt user's data is streaming into our cloud-connected databases. We have only scratched the surface on our planned analyses, but the way we think of data in studies of UL prosthesis control is forever changed. The data is richer too: we can measure in-situ electrode contact quality, diagnose signal or fit issues, monitor proportional speed control usage, evaluate how serious game play metrics can predict device usage, explore how individuals maintain and improve their control, and more.

Looking beyond this new model of data collection, the ultimate benefit is tying the user's day-to-day functional experiences and journey directly to their clinical care team in an objective and quantitative way. Data can be collected and shared with a user's clinical team throughout the entire life of their prosthesis use phases (pre-prosthetic, fitting, in-clinic therapy, post-therapy at-home, long-term). Connecting the powerful user data to the cloud unlocks the power of AI and big-data signal processing to extrapolate important clinical insights. Analyses can provide users and their clinical team with information on functional improvements, positive or negative usage trends, areas of untapped potential, maintenance needs, and more. In fact, approaches to interrelate and link multiple user's myoelectric control data to one another for the benefit of each individual user can be done in ways never before possible.

Historically, two of the major things impeding upper limb myoelectric controls research have been: 1) acquiring ample, representative data of prosthetic use and performance outside the lab, and 2) expanding data collection beyond what has been too simplistic and, in many cases, objectionable device-logged data. Now, using prosthesis control systems in the way that other connected health systems of the world operate has changed the way we conduct R&D and clinical care in this field. The vast quantity and valuable quality of data now collected will connect users, clinicians, and researchers for trusted, functional benefit – the ultimate goal.

Thursday, August 11th

Keynote Address 9:15 AM-10:15 AM

Arun Jayaraman, PT, PhD
Wearable Technologies to enhance O&P Outcome Measurements
Machine learning algorithms that use data streams captured from wearable sensors, smartphones, and camera systems have the potential to automatically detect disease symptoms and inform clinicians about the progression or regression of disease. We will discuss how to design and implement clinical care or research in the field of O&P with wearable technologies. The discussion will touch on choosing the number and type of sensors to place on an individual and which location on the human body is appropriate to measure outcomes in a highly sensitive manner. Does increasing the amount of training data in each individual or adding more individuals lead to improved outcomes measurement? Which clinical tests or functional behaviors are best suited for outcomes measurement? Finally, we will talk about our next generation technology that can be used to monitor O&P component use and mobility at home and in the community and inform clinicians remotely on the state of the individuals under their care.

Dr. Arun Jayaraman is the Director of the Max Nader Center for Rehabilitation Technologies & Outcomes Research; Executive Director of the Technology & Innovation Hub (tiHUB), Shirley Ryan AbilityLab, Chicago, IL, USA; and Professor in the Department of Physical Medicine & Rehabilitation, Department of Physical Therapy & Human Movement Sciences at the Feinberg School of Medicine, Northwestern University, Chicago, USA.

His work primarily focuses on developing and executing both investigator-initiated and industry-sponsored research in prosthetics, orthotics, rehabilitation robotics, assistive and adaptive technologies to treat physical impairments. He conducts all of his outcomes research using advanced wearable patient monitoring wireless sensors and novel machine learning techniques, in addition to the traditional performance-based and patient-reported outcome measures. He collaborates both nationally and internationally with many academic and industrial organizations and is internationally recognized in the field of wearable technologies.

Perspective talk 1 PM-2 PM

Patrick Pilarski
Limbs that keep learning: retrospective and prospective views on constructivism in human-prosthesis interaction
As powered upper-limb prostheses have advanced through technological innovation, new surgical capabilities, and enhanced clinical care and training paradigms, their degree of integration with and impact on the training of their human users has changed dramatically. In particular, and as a focus of this talk, tighter coupling of prostheses with users combined with a rapid step-change in computing capabilities available to prosthesis designers has made it now possible for prosthetic systems to adapt during both training and deployment; more strongly, modern prosthetic technology has the necessary preconditions to construct many key elements of its operation from experience obtained during deployed interactions with users over

extended periods of time. Is this a good thing? The objectives of this talk are to: 1) define "constructivism" and "continual learning" in the context of human interaction with upper-limb prostheses; 2) propose that to realize their full potential, prosthetic control systems and interfaces should be partially or fully constructivist; 3) give concrete examples of how adopting this perspective has exposed beneficial properties in tightly coupled interactions, drawn from our past 10 years of work on developing upper-limb prosthetic interfaces and computational approaches that learn and adapt during their ongoing use (specifically using techniques and viewpoints from the field of reinforcement learning). We hope this talk will provide actionable suggestions and insight for clinical, scientific, and engineering colleagues that is compatible with current thinking, and sparks further dialogue that helps our community as a whole better pursue the design of next-generation prosthetic interventions.

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Podium & Poster Presentations

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Tuesday, August 9th, 2022

UNB Student Union Building

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8:30-9:00am	Vendor Workshop - Ossur (SUB Ballroom)
9:00-9:15am	Welcome Address
9:15-10:15am	Keynote - Max Ortiz Catalán (SUB Ballroom)
10:15-10:45am	Nutrition Break/Vendor Displays (SUB Bottom Floor)
10:45-12:00pm	Session A - Paper Presentations - 5 papers (SUB Ballroom)
12:00-1:00pm	Lunch & Vendor Displays (SUB Bottom Floor)
1:00-1:30pm	Perspective Talk - Jacqueline Hebert (SUB Ballroom)
1:30-2:00pm	Perspective Talk - Ed Iversen (SUB Ballroom)
2:00-3:15pm	Fast-Track Poster Presenters (SUB Ballroom)
	In-Person Poster Session (SUB Atrium)
	Nutrition Break/Vendor Display (SUB Bottom Floor)
3:15-4:30pm	Session B - Paper Presentations - 5 papers (SUB Ballroom)
4:30-4:45pm	End of Day Comments

Paper Session A – 10:45AM-12:00PM

Track	Title	Presenting Author
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Clinical Practice	PPP-ARM: A QUALITY IMPROVEMENT BY INCORPORATING PATIENT INVOLVEMENT AND BY ADDING A DECISION AID FOR TERMINAL DEVICES	Paula Wijdenes
Clinical Practice	CONSENSUS CLINICAL STANDARDS FOR THE PROSTHETIC MANAGEMENT OF UNILATERAL TRANSRADIAL AMPUTATION	Phillip Stevens*
Myo Control and Sensory Feedback Implementations	SKILL ACQUISITION IN PROSTHESIS FORCE CONTROL WITH SUPPLEMENTARY EMG FEEDBACK	Pranav Mamidanna
Myoelectric Control Algorithms	USER-SPECIFIC MIRROR TRAINING CAN IMPROVE MYOELECTRIC PROSTHESIS CONTROL	Troy Tully

*Author to present virtually

Fast Track Poster Presentation (SUB Ballroom)

Poster Session (SUB Bottom Floor)

Nutrition Break/Vendor Displays (SUB Bottom Floor)

2:00PM-3:15PM

(see pg. 30 for listing of posters)

Paper Session B – 3:15PM-4:30PM

Track	Title	Presenting Author
User Experience	A PSYCHOPHYSICAL APPROACH TO MEASURE THE SENSE OF AGENCY	Racheal Steele
User Experience	DATA LOGGING DURING PATTERN RECOGNITION CALIBRATION AS A REMOTE DIAGNOSTIC TOOL	Laura Miller
Myoelectric Control Algorithms	CHARACTERISATION OF MYOELECTRIC ARTEFACTS IN CLINICAL SOCKETS	Alix Chadwell
Myo Control and Sensory Feedback Implementations	TOWARD SEMI-AUTONOMOUS PROSTHETIC HAND CONTROL: APPLYING EMBEDDED NEURAL NETWORKS TO IMPROVE SENSOR FUSION IN PROSTHETIC FINGERTIP SENSORS	Jacob Segil
Myoelectric Control Algorithms	SHARED-CONTROL DECREASES THE PHYSICAL AND COGNITIVE DEMANDS OF MAINTAINING A SECURE GRIP	Marshall Trout

Paper Session A – Abstracts

Theme: Myoelectric Controls Implementations

Abstract Title: RESULTS OF TARGETED MUSCLE REINNERVATION IN INDIVIDUALS WITH A TRANSRADIAL AMPUTATION

Authors: Kristi Turner, Ann Simon, Laura Miller, Levi Hargrove and Todd Kuiken

Abstract: Targeted Muscle Reinnervation (TMR) surgery has been performed for over a decade in individuals with high levels of limb loss (transhumeral and above) to improve their ability to operate a myoelectric prosthesis [1]. However, it is unknown if TMR can improve the ability to operate a multi-articulating hand in individuals with limb loss at the transradial level. The objective of this study was to evaluate whether TMR improves control of a multi-articulating hand using pattern recognition control. A secondary objective was to look at control of a multiarticulating hand with direct control and pattern recognition before TMR surgery (Pre-TMR). Eight individuals with transradial limb loss who had previously used myoelectric control were recruited. Participants were fit with a passive wrist and multiarticulating hand with eight available grips. Home trials were completed Pre-TMR using pattern recognition and direct control, and after TMR (Post-TMR) using pattern recognition control. Occupational therapy was given prior to each home trial for each control type: direct control Pre-TMR, pattern recognition Pre- TMR, and pattern recognition Post-TMR. Outcome measurements were performed at the end of each home trial. A statistically significant improvement was found for both the Jebsen-Taylor Hand Function Test and the Activities Measure for Upper Limb Amputees (AM-ULA), between direct control Pre-TMR and pattern recognition control Post-TMR.

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Theme: Clinical Practice

Abstract Title: PPP-ARM: A QUALITY IMPROVEMENT BY INCORPORATING PATIENT INVOLVEMENT AND BY ADDING A DECISION AID FOR TERMINAL DEVICES

Authors: Paula A. Wijdenes, Nienke Kerver, Sacha van Twillert, Laura Boerema, Michael A.H. Brouwers and Corry K. van der Sluis

Abstract: Introduction: The Prosthesis Prescription Protocol of the upper limb (PPP-Arm), is a digital tool to structure, underpin and evaluate the prescription of upper limb prostheses (ULPs) in rehabilitation centres in the Netherlands that prescribe ULPs. The results of evaluating five years of PPP-Arm use, the recently developed Dutch Quality Standard for Prosthetic Care (D-QSPC) and the wish for facilitating shared decision-making led to this study. We aimed to develop and implement quality improvements and a patient decision aid (PDA) to the national digital protocol PPP-Arm.

Methods: Improvements for PPP-Arm were identified by an evaluation with clinicians after five years of PPP-Arm-usage and based on the recommendations described in the D-QSPC, focussing on new elements that should be incorporated in PPP-Arm. The PDA about Terminal devices for people with Upper Limb Absence (PDA-TULA) was developed in a systematic co-creation process following the steps described by the International Patient Decision Aid Standards. The improved PPP-Arm and the newly developed PDA-TULA were pilot-tested in the real-life national rehabilitation setting.

Results: The following improvements were made to PPP-Arm: the option to add images to the prosthesis application for the health care insurer, access for patients to PPP-Arm in order to complete surveys, digitally signing prosthesis applications, view educational material, and more structure was integrated in the description of the stepped care process. Furthermore, the PDA-TULA was added to PPP-Arm, which informs patients about available Terminal Devices (TDs), then stimulates the patient to consider their own preferences regarding the TD options, and lastly provides an overview of the patients' preferences in relation to the available TD options. Implementation of the pilot-test regarding the improvements of PPP-Arm is ongoing, we expect it will lead to better usability, modernization, and increased patient involvement in the treatment process. Pilot-testing of the PDA-TULA showed that patients and clinicians experienced benefits from the PDA-TULA regarding the prosthesis selection process.

Conclusion: PPP-Arm has been improved, adjusted to the renewed D-QSPC, and supplemented with the PDA-TULA. Results emphasize the importance to cooperate with all stakeholders and pilot-test changes and new products in the real-life setting to develop and improve products that suits the needs of all stakeholders.

Theme: Clinical Practice

Abstract Title: CONSENSUS CLINICAL STANDARDS FOR THE PROSTHETIC MANAGEMENT OF UNILATERAL TRANSRADIAL AMPUTATION

Authors: Erin O'Brien, Phillip Stevens, Steve Mandacina and Craig Jackman

Abstract: Consensus clinical standards of care were recently developed through three rounds of Delphi consensus surveys. The 40 statements that reached consensus standards for inclusion encompassed indications for general prosthetic consideration, as well as indications and considerations for body powered, externally powered and oppositional silicone restoration prostheses, terminal device selection, the selection of body powered control strategies, considerations for moisture, debris or heavy duty use, activity specific prostheses and indications for multiple terminal devices. These standards may serve to guide clinical decision making and inform medical policy.

Theme: Myoelectric Controls Implementations

Abstract Title: SKILL ACQUISITION IN PROSTHESIS FORCE CONTROL WITH SUPPLEMENTARY EMG FEEDBACK

Authors: Pranav Mamidanna, Shima Gholinezhad, Jakob Dideriksen and Strahinja Dosen

Abstract: Supplementary feedback interfaces for myoelectric prostheses enable users to learn, plan and execute the movements for controlling their prostheses. The ability to execute these movements reliably and accurately – ‘skill,’ can be studied by assessing speed-accuracy trade-offs (SAF). Here we used the SAF framework to empirically investigate skill acquisition with a closed-loop interface that uses EMG feedback, during a functional prosthesis force-control task. Preliminary results suggest that over 3 days the SAF shifts vertically upwards, while its shape remains consistent. Faster grasping remained less accurate compared to when participants used the supplementary feedback to carefully guide their behavior. We believe that studying the SAF not only enables us to quantify skill acquisition or learning effects, but also to more broadly understand the performance characteristics of closed-loop user-prosthesis interfaces.

MEC22

Theme: Myoelectric Controls Algorithms

Abstract Title: USER-SPECIFIC MIRROR TRAINING CAN IMPROVE MYOELECTRIC PROSTHESIS CONTROL

Authors: Troy Tully, Caleb Thomson, Gregory Clark and Jacob George

Abstract: State-of-the-art transradial prostheses can provide intuitive and proportional myoelectric control by training an algorithm to correlate surface electromyographic signals from the residual forearm muscles to intended movements of the amputated hand. One training paradigm, “mimicked training,” relies on amputees mimicking a prosthetic hand with their missing hand such that the corresponding muscle activations are correlated to the preprogrammed kinematics of the prosthetic hand. A second training paradigm, “mirrored training,” relies on unilateral amputees mirroring their contralateral hand with their missing hand such that the muscle activations are correlated to the kinematics of the contralateral hand (determined via a motion capture). Prior work with intact participants demonstrated that the kinematics of a given hand are more closely related to that of an individual’s contralateral hand as opposed to the preprogrammed kinematics of a prosthesis. This abstract continues our investigation into the training data for myoelectric prostheses by exploring the impact of these training paradigms on real-time prosthetic control with amputees completing a functional task. For one out of three participants, mirrored training significantly improved task performance. These preliminary results demonstrate that mirrored training may provide more dexterous control through task-specific user-chosen training data. These results can guide myoelectric training for proportional and dexterous control.

Paper Session B – Abstracts

Theme: User Experience

Abstract Title: A PSYCHOPHYSICAL APPROACH TO MEASURE THE SENSE OF AGENCY

Authors: Racheal Steele, Ahmed Shehata, Jon Sensinger, Jacqueline Hebert and Dan Blustein

Abstract: Increasing a prosthesis user's sense of agency over their device may lead to improved patient outcomes. Measuring agency, however, can be difficult. Widely used questionnaires may be prone to cognitive biases and an established proxy for agency, the intentional binding paradigm, can be attentionally demanding. In this study, we present and test a novel psychophysical time discrimination task to detect the intentional binding effect, i.e. the perceived compression of the time interval between a controlled action and its effect. The task uses a two-alternative forced choice time comparison task to avoid the attentional demands associated with temporal estimation using an auxiliary clock display (such as a standard Libet clock protocol). We show that the psychophysics protocol can detect the intentional binding effect during voluntary movements in a small pilot study (n=4). Participants also completed a standard Libet clock protocol that showed inconsistent results. We conclude with a discussion of protocol improvements. The psychophysical time discrimination assessment shows promise for use as an objective sense of agency metric suitable for prosthesis users.

Theme: User Experience

Abstract Title: DATA LOGGING DURING PATTERN RECOGNITION CALIBRATION AS A REMOTE DIAGNOSTIC TOOL

Authors: Laura Miller, Kristi Turner and Annie Simon

Abstract: Pattern recognition control uses EMG from the entire residual limb to more intuitively control prosthetic devices. However, this requires a more intimate socket fit to maintain contact with these additional sensors. When users complain of issues with control, it can be difficult to diagnose if the issue is a need for additional practice and training or if there are issues related to the prosthetic fit that need to be addressed. Since pattern recognition allows the recalibration of the system by the user in any location, there is the opportunity to use this feature to assist in troubleshooting issues remotely. By analysing the data logging of calibration data in a pattern recognition system, it is possible to better identify the cause and potential solution in a remote setting.

Theme: Myoelectric Controls Algorithms

Abstract Title: CHARACTERISATION OF MYOELECTRIC ARTEFACTS IN CLINICAL SOCKETS

Authors: Alix Chadwell and Matthew Dyson

Abstract: A significant disparity exists between the functionality promised by modern multi-grip myoelectric prostheses and the reality of myoelectric control using clinical-standard sockets and electrodes. Unpredictable prosthesis behaviour means users will often choose not to use their prosthesis for certain tasks. One source of unpredictability in upper-limb prostheses are unintended device activations, that is to say prostheses opening or closing when the user did not intend for the action to occur. Unintended device activations occur when the output of electromyography sensors reach a given threshold. During closed-loop control it is usually not possible to determine whether sensors reach threshold due to mechanical disturbances inducing motion artefacts or because of genuine, but unintended, muscle activity. We present preliminary data from experiments which use arrays of sensors to characterise how and why artefacts may occur in clinical-standard upper-limb prosthesis sockets. Current data show early trends in physical positions which lead to unintended activation and shows some artefacts are concurrent with intended muscle activity.

Theme: Myoelectric Controls Implementations

Abstract Title: TOWARD SEMI-AUTONOMOUS PROSTHETIC HAND CONTROL: APPLYING EMBEDDED NEURAL NETWORKS TO IMPROVE SENSOR FUSION IN PROSTHETIC FINGERTIP SENSORS

Authors: Ben Pulver, Sarah Aguasvivas Manzano, Aaron Selnick, Serena Kishek, Levin Sliker, Nikolaus Correll and Jacob Segil

Abstract: We present an application of embedded, real-time neural network predictions to produce reliable sensing and enable semi-autonomous control of a prosthetic hand with embedded tactile sensors at the fingertips. We simultaneously predict the force magnitude and the position of contact, requiring on average 32.8ms, thereby enabling real-time measurements. We demonstrate 97.2% offline classification accuracy on the contact position, and a root mean squared error of 1.38 N (mean absolute error of 0.68 N) in predicting the force magnitude. Neural networking training is performed off-line on a Desktop computer using Keras, and compiled into efficient C-code for a nrf52840 microcontroller using the open-source tool "nn4mc." The training model, as well as the nn4mc compiler, are available online, allowing prosthetic engineers to incorporate real-time, sensor-based inference into their prosthetic design.

MEC22

Theme: Myoelectric Controls Algorithms

Abstract Title: SHARED-CONTROL DECREASES THE PHYSICAL AND COGNITIVE DEMANDS OF MAINTAINING A SECURE GRIP

Authors: Marshall A. Trout, Taylor C. Hansen, Connor D. Olsen, David J. Warren, Jacob L. Segil and Jacob A. George

Abstract: Upper-limb amputees commonly cite difficulty of control as one of the main reasons why they abandon their prostheses. Combining myoelectric control with autonomous sensor-based control could improve prosthesis control. However, the cognitive and physical impact of shared control and semi-autonomous systems on users has yet to be fully explored. In this study we introduce a novel shared-control algorithm that blends proportional position control predicted from electromyography (EMG) with proportional position control predicted from an autonomous machine using infrared sensors embedded in the prosthetic hand's fingers to detect the distance to objects. The user's EMG control is damped in proportion to the machine's prediction of an object's position in relation to a given finger. The shared-control algorithm was validated using three intact individuals completing a holding task where they attempted to hold an object for as long as possible without dropping it. Shared control resulted in fewer object drops, 32% less cognitive demand, and 49% less physical effort (measured by EMG) relative to the participant's EMG control alone. These results indicate that shared control can reduce the physiological burdens on the user as well as increase prosthetic control.

Day 2

Wednesday, August 10th, 2022

UNB Student Union Building

Day at-a-glance	
7:30am	Registration Desk Opens (SUB Bottom Floor)
8:00-8:30am	Buffet Breakfast (SUB Ballroom)
	Vendor Workshop - Point Designs (SUB Ballroom)
8:30-9:00am	Vendor Workshop - Aether Biomedical (SUB Ballroom)
9:00-9:15am	Morning Comments
9:15-10:15am	Keynote - Matthew Ames (SUB Ballroom)
10:15-10:45am	Nutrition Break/Vendor Displays (SUB Bottom Floor)
10:45-12:00pm	Session C - Paper Presentations - 5 papers (SUB Ballroom)
12:00-1:00pm	Lunch / Vendor Displays (SUB Bottom Floor)
1:00-1:30pm	Perspective Talk - Dick Plettenburg (SUB Ballroom)
1:30 - 2:00pm	Perspective Talk - Blair Lock (SUB Ballroom)
2:00 – 3:15pm	Virtual Poster Session (Gathertown) Nutrition Break/Vendor Displays (SUB Bottom Floor)
3:15 – 4:30pm	Session D - Paper Presentations - 5 papers (SUB Ballroom)
4:30-4:15	End of Day Comments

Paper Session C – 10:45AM-12:00PM

Track	Title	Presenting Author
Myoelectric Controls Algorithms	ROBUSTNESS OF FREQUENCY DIVISION TECHNIQUE IN A SIMULTANEOUS AND PROPORTIONAL MYOELECTRIC CONTROL SCHEME	Ashirbad Pradhan*
	TRAINING PROSTHESIS CONTROL IN THE LAB AND THE HOME	Simon Stuttaford
	MOTOR UNIT SUBSET SELECTION FOR SCALABLE REAL-TIME INTERFACING	Dennis Yeung*
Other	DISENTANGLING SENSORY AND MOTOR DEFICITS OF FINE HAND FUNCTION USING AN ELECTRONIC GRIP GAUGE (EGG) TO SIMULATE TRANSFERRING FRAGILE OBJECTS	Monika Buczak
Prosthetic Devices / Materials	A TRANSRADIAL MODULAR ADAPTABLE PLATFORM FOR EVALUATING PROSTHETIC FEEDBACK AND CONTROL STRATEGIES	Ahmed Shehata

*Author to present virtually

Virtual Poster Session (Gathertown)

Nutrition Break/Vendor Displays (SUB Bottom Floor)

2:00PM-3:15PM

(see pg. 30 for listing of posters)

Paper Session D – 3:15PM-4:30PM

Track	Title	Presenting Author
Clinical Research	IMPACT OF UNILATERAL TRANSRADIAL PROSTHESIS IN UPPER LIMB UTILIZATION RELATIVE TO ABLE-BODIED CONTROLS: INSIGHTS FROM WIRELESS ACCELEROMETER DATA	Phillip Stevens
	THE EFFECT OF SERIOUS GAME TRAINING ON UPPER LIMB PROSTHESIS CONTROL IN THE HOME ENVIRONMENT	Bart Maas
Prosthetic Devices / Materials	AN INEXPENSIVE AND ADAPTABLE PROSTHETIC WRIST IMPROVES DEXTERITY AND REDUCES COMPENSATORY MOVEMENTS	Connor Olsen
	FUNCTIONALLY VIABLE 3D PRINTED POLYMER TRANSRADIAL FRAME AND WRIST WITH VARIABLE COMPLIANCE DYNAMIC VOLUME SOFT SOCKET WITH INCREASED BREATHABILITY AND RANGE OF MOTION	Jonathan Kuniholm
User Experience	A PLATFORM TO ASSESS BRAIN DYNAMICS REFLECTIVE OF COGNITIVE LOAD DURING PROSTHESIS USE	Oscar Ortiz

Paper Session C – Abstracts

Theme: Myoelectric Controls Algorithms

Abstract Title: ROBUSTNESS OF FREQUENCY DIVISION TECHNIQUE IN A SIMULTANEOUS AND PROPORTIONAL MYOELECTRIC CONTROL SCHEME

Authors: Ashirbad Pradhan, Ning Jiang, Wendy Hill, Victoria Chester and Usha Kuruganti

Abstract: It is important for myoelectric control schemes to be robust to various non-stationarities in electromyography (EMG) signal such as unintended activations and contraction level variations. In order to address this limitation, the present study compared performance measures of two EMG processing pipelines with two filtering techniques: frequency division technique (FDT) and standard bandpass processing (Bandpass) in a simultaneous and proportional myoelectric control (SPEC) scheme for two contraction levels (medium and high). Twenty able-bodied participants (14 males and 6 females, age 23.4 ± 3.0) performed wrist movements (flexion/extension, rotations and combined movements) in two degrees-of freedom (DOF) virtual tasks. FDT had a mean completion rate (CR) of 95.33%, which was significantly higher than the SPB technique with a CR of 64.08% ($p<0.001$). FDT method performed significantly better in all other performance indices in at least one movement type. Furthermore, there was no significant difference in the performance of FDT between medium and high contraction levels, while there were such differences for bandpass filtering. This study showed that FDT is advantageous in regression based online myoelectric control as it generates a more accurate, robust and contraction level invariant scheme for performing prosthetic hand movements. This study is the first to use frequency-based features with a SPEC scheme and shows promise for more intuitive prosthetic devices.

Theme: Myoelectric Controls Algorithms

Abstract Title: TRAINING PROSTHESIS CONTROL IN THE LAB AND THE HOME

Authors: Simon Stuttaford, Sigrid Dupan, Kianoush Nazarpour and Matthew Dyson

Abstract: Historically, experiments involving motor learning-based control schemes use real-time feedback. It is unclear, to what extent previous results are attributable to transient performance effects caused by closed loop adaptive processes, rather than motor learning. To investigate, we performed two long-term experiments. Experiment 1: a lab-based study compared use of continuous and delayed visual feedback to assess long-term stability of skill retention; we trained ten participants using either continuous or delayed visual feedback over four consecutive days with a follow-up probe on week three. Experiment 2: a home-based study validated that the training protocols introduced in experiment one can train forward models outside of the laboratory in an appropriate period. Three participants trained over five days with a goal of maximising proficiency via bespoke training structures.

Theme: Myoelectric Controls Algorithms

Abstract Title: MOTOR UNIT SUBSET SELECTION FOR SCALABLE REAL-TIME INTERFACING

Authors: Dennis Yeung, Francesco Negro and Ivan Vujaklija

Abstract: Current methods for motor unit (MU) based human-machine interfacing do not scale well with the expansion of output functionality. This is due to the high computational demands of the initial MU parameter extraction via decomposition of high-density surface electromyography recordings. We propose an alternative approach that relies on task-specific batch decomposition processes along with a MU subset selection step to address feature redundancy. Offline analyses were conducted using EMG and kinematics pertaining to 18 wrist/forearm motor tasks recorded from 11 able-bodied subjects. The mutual information-based minimal Redundancy Maximal Relevancy (mRMR) feature selection framework was tested and compared to Maximal Relevancy (MR) and two arbitrary selection methods. Subset MUs were then used for joint kinematics estimation corresponding to those 18 motor tasks by three different regressors. The mRMR selection scheme was found to retain MUs with the highest predictive power. When the portion of tracked MUs was reduced to 25%, regression accuracy decreased by only 3.5%.

MEC22

Theme: Prosthetic Devices / Materials

Abstract Title: A TRANSRADIAL MODULAR ADAPTABLE PLATFORM FOR EVALUATING PROSTHETIC FEEDBACK AND CONTROL STRATEGIES

Authors: Ben W. Hallworth, Ahmed W. Shehata, Michael Dawson, Florian Sperle, Mathilde Connan, Werner Friedl, Bernhard Vodermayer, Claudio Castellini, Jacqueline Hebert and Patrick M. Pilarski

Abstract: Novel multi-modal and closed-loop myoelectric control strategies may yield more robust, capable prostheses which improve quality of life for those affected by upper-limb loss. However, the translation of such systems from an experimental setting towards daily use by persons with limb loss is limited by the cost and complexity of assessing all the possible sensor and feedback configurations. The comparison of different control strategies is further complicated by the use of disparate prosthetic socket and simulated prosthesis designs across experiments. This study aims to address these issues through the development and preliminary assessment of a Modular-Adaptable Prosthetic Platform (MAPP) system for use in experimental control strategy evaluation. The MAPP system is compatible with a variety of commercially available control and feedback devices and can be used in experiments involving participants with either intact or amputated limbs. The modular design enables compatibility with novel devices and quick reconfiguration of components. We compared EMG and FMG data acquired with the MAPP system to a previously characterized transradial simulated prosthesis, using able-bodied subjects. The MAPP was shown to match or exceed the control accuracy achieved using a rigid simulated prosthesis, while providing the added benefits of modularity. This device shows promise as a research tool which can catalyze the deployment of advanced control strategies by enabling comprehensive and standardized assessment of control and feedback strategies

MEC22

Theme: Other

Abstract Title: DISENTANGLING SENSORY AND MOTOR DEFICITS OF FINE HAND FUNCTION USING AN ELECTRONIC GRIP GAUGE (EGG) TO SIMULATE TRANSFERRING FRAGILE OBJECTS

Authors: Monika Buczak, Brandon Baum, Connor Olsen and Jacob George

Abstract: Evaluating hand dexterity is a critical aspect of assessing novel prosthetic technology and informing patient care. Current upper-limb dexterity assessments primarily target gross motor function and do not directly measure the ability of an individual to finely regulate their grip force. An increasingly popular test of fine motor function among researchers is a fragile-object test, in which participants are instructed to lift and transfer an object while minimizing their applied grip force. Here we present another instantiation of this fragile-object test, dubbed the electronic grip gauge (EGG). We use the EGG to quantify grip force and transfer rate for intact hands and myoelectric prostheses under three distinct conditions: 1) implicit grasping when transferring the object as fast as possible, 2) grasping when participants are instructed to minimize their grip force using endogenous tactile feedback and/or indirect sensory feedback, and 3) grasping when participants are instructed to minimize their grip force and have auditory feedback proportionate to their grip force. We show that a lack of tactile feedback is a significant reason for poor prosthetic control, as evidenced by significantly better prosthetic control with auditory feedback. We also show that even with supplemental auditory feedback, the performance of the prosthetic hand was still substantially worse than the performance of the intact hand. These results suggest that artificial sensory feedback can improve prosthetic control, but that improvements in mechanical design and/or real-time control are also needed to replicate the dexterity of intact human hands.

Paper Session D – Abstracts

Theme: User Experience

Abstract Title: A PLATFORM TO ASSESS BRAIN DYNAMICS REFLECTIVE OF COGNITIVE LOAD DURING PROSTHESIS USE

Authors: Oscar Ortiz, Usha Kuruganti and Daniel Blustein

Abstract: Prosthetic hand operation often results in high levels of cognitive burden on the user which can lead to fatigue, frustration and device rejection. Previous work that quantified this cognitive load relied on subjective questionnaires or distraction tasks. We have adapted a protocol capable of real-time, objective, non-distracting assessment of cognitive load for use with individuals controlling a myoelectric prosthesis. Here we present this platform to assess cortical dynamics during prosthesis use. We describe a custom-built lightweight prosthesis simulator and an electroencephalography (EEG) assessment. We also present pilot work that shows how alpha inhibitory activity recorded with a wireless EEG system can be used to assess brain dynamics reflective of cognitive tasks as well as motor tasks.

Theme: Prosthetic Devices / Materials

Abstract Title: AN INEXPENSIVE AND ADAPTABLE PROSTHETIC WRIST IMPROVES DEXTERITY AND REDUCES COMPENSATORY MOVEMENTS

Authors: Connor D. Olsen, Eric S. Stone, Troy N. Tully, Nathaniel R. Olsen, Gregory A. Clark and Jacob A. George

Abstract: Many presently available prostheses lack a functional wrist. Here, we highlight the development of an inexpensive prosthetic wrist that can be adapted to work with various sockets and prostheses. Using this prosthetic wrist, we explore the functional and cognitive impact of using a prosthetic wrist to perform activities of daily living. We measured task performance, compensatory movements, and cognitive load while transradial amputees performed a Clothespin Relocation Task (CRT) using a prosthesis attached to the wrist controlled by surface electromyography (EMG). Three transradial amputees performed the task with and without EMG control of the wrist. Use of the prosthetic wrist significantly improved task success rate from 33% ± 13% to 61% ± 9% (mean ± standard error). Use of the prosthetic wrist also significantly reduced compensatory movements; the maximum leftward bend at the hip decreased from 18.9° ± 1.2° to 15.0° ± 1.4°. The addition of controlling a prosthetic wrist had no significant impact on cognitive load, as assessed by the NASA Task Load Index survey and the detection response time to a secondary task. This work suggests that using a prosthetic wrist may increase dexterity and reduce joint strain for amputees without requiring a significant increase in cognitive effort compared to that of EMG control of a hand alone. These results can guide future development and prescription of upper-limb prostheses.

MEC22

Theme: Prosthetic Devices / Materials

Abstract Title: FUNCTIONALLY VIABLE 3D PRINTED POLYMER TRANSRADIAL FRAME AND WRIST WITH VARIABLE COMPLIANCE DYNAMIC VOLUME SOFT SOCKET WITH INCREASED BREATHABILITY AND RANGE OF MOTION

Authors: Jonathan Kuniholm and Zachary Meyer

Abstract: Nine of the top ten reasons that half of arm amputees reject prostheses are related to dissatisfaction with fit and comfort, primarily of sockets [1]. Traditional (particularly myoelectric) sockets severely limit range of motion (ROM), and create pressure, heat and moisture management, and tissue breakdown issues. Here we describe preliminary results from the testing of a new design of transradial frame and socket that combines advanced modern soft athletic shoe materials and construction with 3D printed frame counters to create a functionally viable 3D printed arm with integrated wrist and variable compliance socket weighing less than two pounds complete with harness and terminal device. The system has been used for cross country skiing and indoor rowing, sustaining hours of use in sweaty and friction-rich environments. The range of motion of the prosthesis was measured as compared to anatomical, showing a 59% improvement over a Veterans Affairs (VA) Hospital-provided self-suspending myoelectric socket. The arm and harness can bear tensile loads more than 50 pounds. Custom one-hand operable harness hardware can bear 65 pounds with a factor of safety of more than three.

MEC22

Theme: Clinical Research

Abstract Title: THE EFFECT OF SERIOUS GAME TRAINING ON UPPER LIMB PROSTHESIS CONTROL IN THE HOME ENVIRONMENT

Authors: Bart Maas, Zack Wright, Corry Van Der Sluis and Raoul Bongers

Abstract: Background: The focus of the field of upper limb prosthesis has primarily been on lab-based studies, while user-complaints do hardly change. Focus should shift to home use training and assessment. The current paper establishes whether training with serious games in the home setting affect upper limb prosthesis activation signals in Pattern Recognition controlled prostheses.

Method: Ten upper limb prosthesis users were measured for a period of two weeks and were instructed to play serious games for at least 45 minutes per week. The activation signals before and after a serious game was played during daily life were measured. The activation signals were classified in involuntary and voluntary activations.

Results: More involuntary activation signals than voluntary activation signals were recorded. Second, no effects of serious game training on activation signals in daily life were found.

Conclusion: Even though no effect of serious game training was found, our findings show that recording and analyzing data derived from prosthesis users' daily life is feasible. However, much has still to be learned about the storage, applicability and meaning of this data. Our research underlines the importance of transitioning from lab-based research to research in daily life.

MEC22

Theme: Clinical Research

Abstract Title: IMPACT OF UNILATERAL TRANSRADIAL PROSTHESIS IN UPPER LIMB UTILIZATION RELATIVE TO ABLE-BODIED CONTROLS: INSIGHTS FROM WIRELESS ACCELEROMETER DATA

Authors: Phillip Stevens, Binal Motawar, Kelli Buchanan and Scott Frey

Abstract: Hand loss profoundly impacts daily functioning. The use of an upper limb prosthesis can restore a measure of both unimanual and bimanual upper limb function for this population. We asked unilateral, transradial amputees (N=22) and healthy controls (N=20) to wear wireless accelerometers on their forearms and distal prostheses, as well as on their upper arms bilaterally to capture data over 3 days while the subjects were in their natural environments. Prosthesis users wore their devices an average of 11 hours/day. They exhibited heavier reliance on their sound side upper limb than on their affected limb. However, they were observed to engage in unimanual activity with their prostheses an average of 20 minutes/day compared to the 60 minutes of mean unimanual activity observed in the non-dominant extremity of control subjects. Bimanual activity among prosthesis users was recorded for an average of 4 hours/day compared to an average of 5 hours/day in the control population. While participants generally exhibited 70% reliance on their lower arm segment relative to their upper arm segment, on the affected extremity of the amputee participants, this reliance dropped to 50%, suggesting a need for greater upper arm activity to preposition the prosthesis in space. Upper arm accelerometers confirmed that engagement of the upper arm segment in upper limb amputees diminish when the prosthesis is removed. Collectively, this data begins to demonstrate the ability of transradial prostheses to preserve both unimanual and bimanual functionality. (This abstract focuses on a subset of previously published data from Frey S, Motawar B, Buchanan K, et al. Greater and more natural use of upper limbs during everyday life by former amputees versus prosthesis users. Neurorehabil Neur Rep. 2022;36(3):227-38).

Day 3
Thursday, August 11th, 2022
UNB Student Union Building

Day at-a-glance	
7:30am	Registration Desk Opens (SUB Bottom Floor)
8:00-8:30am	Buffet Breakfast (SUB Ballroom) Vendor Workshop - Naked Prosthetics (SUB Ballroom)
8:30-9:00am	Vendor Workshop - Aether Biomedical (SUB Ballroom)
9:00-9:15am	Morning Comments
9:15-10:15am	Keynote - Dr. Arun Jayaraman (SUB Ballroom)
10:15-10:45am	Nutrition Break/Vendor Displays (SUB Bottom Floor)
10:45-12:00pm	Session E - Paper Presentations - 5 papers (SUB Ballroom)
12:00-1:00pm	Lunch Vendor Displays (SUB Bottom Floor)
1:00-1:30pm	Perspective Talk - Patrick Pilarski (SUB Ballroom)
1:30 - 2:15pm	Session F - Paper Presentations - 3 papers (SUB Ballroom)
2:15 - 2:45pm	Nutrition Break/Vendor Displays (SUB Bottom Floor)
2:45 - 3:45pm	Session G - Paper Presentations - 4 papers (SUB Ballroom)
3:45 - 4:15pm	Closing Remarks

Paper Session E – 10:45AM-12:00PM

Track	Title	Presenting Author
Prosthetic Devices/Materials	PRELIMINARY ACTIVITIES TOWARDS A BATTERY CONSUME OPTIMIZATION ALGORITHM FOR PROSTHETIC HAND	Alessandro Varalda
Clinical Research	EFFECT OF MULTI-GRIP MYOELECTRIC HANDS ON DAILY ACTIVITIES, PAIN-RELATED DISABILITY AND PROSTHESIS USE COMPARED WITH SINGLE-GRIP PROSTHESES	Cathrine Widehammar
	MUSCULOSKELETAL COMPLAINTS AND HUMAN ASSUMED CENTRAL SENSITISATION IN INDIVIDUALS WITH BRACHIAL PLEXUS INJURY AND UPPER LIMB ABSENCE.	Anneliek Peters
	ADAPTIVE EMG PATTERN RECOGNITION REDUCES FREQUENCY AND IMPROVES QUALITY OF AT-HOME PROSTHESIS TRAINING FOR UPPER LIMB MYOELECTRIC PROSTHESIS WEARERS	Zachary Wright
Myoelectric Controls Implementations	DEEP AND SURFACE MODALITIES FOR MYO-INTENT DETECTION	Mathilde Connan

Paper Session F – 1:30PM-2:15PM

Track	Title	Presenting Author
User Experience	CHARACTERIZING SELF-REPORTED PROSTHESIS USE IN EVERYDAY TASKS	Linda Resnik*
Prosthetic Devices / Materials	A PILOT EVALUATION OF KINEMATIC CHANGES WITH POWERED WRIST FLEXION FOR TRANSRADIAL PROSTHETIC USERS USING THE GAZE AND MOVEMENT ASSESSMENT (GAMA) METRIC	Laura Miller
Clinical Research	WELL-BEING AMONG INDIVIDUALS WITH UPPER LIMB AMPUTATION IS STRONGLY CORRELATED WITH BIMANUAL UPPER LIMB FUNCTION, ACTIVITY AND PARTICIPATION LEVELS, PROSTHETIC SATISFACTION AND LOWER RATES OF PAIN INTERFERENCE	Phillip Stevens

*Author to present virtually

Paper Session G – 2:45PM-3:45PM

Track	Title	Presenting Author
Myoelectric Controls Algorithms	TAKE-HOME TRIAL OF THE GLIDE HAND AND WRIST MYOELECTRIC CONTROL ALGORITHM: A CASE STUDY	Chris Baschuk
	DEMONSTRATION OF AN OPTOGENETIC NEURONAL CONTROL INTERFACE	Arjun Fontaine
	ASSESSING THE FEASIBILITY OF USING SONOMYOGRAPHY FOR UPPER LIMB PROSTHESIS CONTROL	Susannah Engdahl*
Clinical Research	THE EFFECT OF SENSORY FEEDBACK ON THE TEMPORAL ALLOCATION OF GAZE USING A SENSORIZED MYOELECTRIC PROSTHESIS	Jacqueline Hebert

*Author to present virtually

Paper Session E – Abstracts

Theme: Prosthetic Devices / Materials

Abstract Title: PRELIMINARY ACTIVITIES TOWARDS A BATTERY CONSUME OPTIMIZATION ALGORITHM FOR PROSTHETIC HAND

Authors: Alessandro Varalda, Burim Kabashi and Marco Controzzi

Abstract: Optimization of the power consumption in Myoelectric hand prosthesis is a crucial issue that can affect the autonomy of the user and the weight of the device. This aspect seems to be barely addressed nowadays. Here we propose a high-level solution

that can be implemented on a prosthetic hand, which combines a Current Sharing Algorithm and a Battery Management System with Optimal Output Current to: i) satisfy the daily requirements in terms of grasps and time, ii) enhance the battery life. This

solution has been preliminarily implemented on the Mia Hand prosthesis (Prensilia SRL) showing promising results.

MEC22

Theme: Clinical Research

Abstract Title: EFFECT OF MULTI-GRIP MYOELECTRIC HANDS ON DAILY ACTIVITIES, PAIN-RELATED DISABILITY AND PROSTHESIS USE COMPARED WITH SINGLE-GRIP PROSTHESES

Authors: Cathrine Widehammar, Ayako Hiyoshi, Kajsa Lidström Holmqvist, Helen Lindner and Liselotte Hermansson

Abstract: Objective: To evaluate the effect of multi-grip hands on performance of daily activities, pain-related disability and prosthesis use, in comparison to single-grip hands. Design: Single-case AB design. Patients: Nine adults with upper-limb loss participated. All had previous experience of single-grip myoelectric prostheses and were prescribed a prosthesis with multi-grip functions. Methods: To assess the changes in daily activities, pain-related disability and prosthesis use between single-grip and multi-grip prosthetic hands, the Canadian Occupational Performance Measure, Pain Disability Index, and prosthesis wearing time were measured at multiple occasions. Visual assessment of graphs and multi-level linear regression were used to assess changes in the outcome measures, adjusting for xx, yy, and zz. Results: At 6 months' follow-up self-perceived performance and satisfaction scores increased, prosthesis wearing time increased, and pain-related disability reduced in participants with musculoskeletal pain at baseline. On average, 8 of the 11 available grip types were used. Most useful were the power grip, tripod pinch and lateral pinch. Conclusion: The multi-grip hand appears to be associated with higher performance and satisfaction of individually chosen activities, increased prostheses use and lower pain-related disability. A durable single-grip hand may still be needed for heavier physical activities. With structured training a standard two-site electrode control system can be used to operate a multi-grip hand.

MEC22

Theme: Clinical Research

Abstract Title: MUSCULOSKELETAL COMPLAINTS AND HUMAN ASSUMED CENTRAL SENSITISATION IN INDIVIDUALS WITH BRACHIAL PLEXUS INJURY AND UPPER LIMB ABSENCE.

Authors: Anneliek A. Peters, Sietke G. Postema, Hans Timmerman, Corry K. van der Sluis and Michiel F. Reneman

Abstract: Background: Musculoskeletal complaints (MSCs) are a highly prevalent problem in subjects with upper limb absence (ULA) and Brachial Plexus Injury (BPI). Single-handed individuals often experience pain in multiple locations. Human Assumed Central Sensitisation (HACS) can be present in single-handed individuals. This study aims to determine the presence of HACS in single-handed individuals with MSCs compared to individuals without MSCs as well as two-handed controls.

Methods: This study aims to include 20 individuals with ULA, 20 with BPI, and matched two-handed controls. All participants filled in the Central Sensitisation Inventory (CSI) questionnaire (range 0-100, cut off value for CS ≥ 40). Furthermore, they underwent a Quantitative Sensory Testing (QST) protocol. Seven sensory tests were executed to quantify the function of the sensory nervous system: dynamical mechanical allodynia (DMA, range 0-100), mechanical detection threshold (MDT, range 0.125-1024mN), mechanical pain threshold & sensitivity (MPT, range 8-1024mN & MPS, range 0-100), wind-up ratio (WUR, ratio), and pressure pain threshold & sensitivity (PPS in N & PPT, range 0-100).

Results: Data collection is ongoing. At present, data of seven individuals with BPI are collected. CSI mean is 24 (SD 11.0). QST: DMA [1.0], MDT [1.3-1024.0mN], MPT [19.2-1024mN], MPS [0.6-25], WUR [1.33-4.5], PPS [27.5-138.0N], and PPT [1-50].

Conclusion: Preliminary results indicate that CS may be present in a subgroup of single-handed individuals with MSCs. This study sheds light on the role of CS in single-handed individuals and could give more insight in the frequently occurring MSCs in such individuals.

Theme: Clinical Research

Abstract Title: ADAPTIVE EMG PATTERN RECOGNITION REDUCES FREQUENCY AND IMPROVES QUALITY OF AT-HOME PROSTHESIS TRAINING FOR UPPER LIMB MYOELECTRIC PROSTHESIS WEARERS

Authors: Zachary Wright and Blair Lock

Abstract: Upper limb myoelectric pattern recognition-controlled prostheses use machine learning algorithms to identify a wearer's intended movement from their muscle activity patterns. However, many factors can contribute to changes in the characteristics of the EMG input signals (electrode shift, muscle fatigue, limb position etc.) during everyday prosthesis use which can diminish controller performance. Multiple in-lab studies have demonstrated promising results towards improving controller performance by employing advanced algorithms, none of which have been tested clinically, that can adapt to these changes. This paper presents the implementation of a supervised-adaptation algorithm on a commercially available pattern recognition control system that makes use of historical EMG data collected during previous user-initiated calibration routines to update the existing classification model. In an at-home clinical study, we evaluated whether real-world use of adaptive classification reduces how often upper limb prosthesis wearers need to recalibrate their pattern recognition system.

Theme: Myoelectric Controls Implementations

Abstract Title: DEEP AND SURFACE MODALITIES FOR MYO-INTENT DETECTION

Authors: Mathilde Connan, Bingbin Yu, Christian Gibas, Rainer Brück, Elsa Kirchner and Claudio Castellini

Abstract: Electromyography is the gold-standard among sensors for prosthetic control. However, stable and reliable myocontrol remains an unsolved problem in the community. Amid improvements currently under investigation, one focuses on alternative or complementary sensors. In this study, we compare different techniques, recording surface and deep muscle activity. Ten subjects were involved in an experiment in which three different modalities were attached on their forearm: force myography, electro-impedance tomography and ultrasound. They were asked to perform wrist and grasp movements. For the first time, we evaluate and compare in an offline analysis these three different modalities while recording several hand gestures.

Paper Session F - Abstracts

Theme: User Experience

Abstract Title: CHARACTERIZING SELF-REPORTED PROSTHESIS USE IN EVERYDAY TASKS

Authors: Linda Resnik, Matthew Borgia, Allen Heinemann, Phillip Stevens and Pensheng Ni

Abstract: A sample of 411 individuals with either unilateral or bilateral upper limb amputation (ULA) reported prostheses engagement when they performed a spectrum of common one- and two-handed tasks. We compared frequency of performing one- and two-handed activities by laterality (unilateral versus bilateral), by amputation level (for unilateral amputees), and by type of prosthesis used (for unilateral transradial amputees). A greater proportion of persons with bilateral amputations reported engaging their prosthesis in both one- and two-handed tasks. Those with more proximal amputation engaged their prostheses in fewer activities, and persons using myoelectric single degree of freedom devices engaged their prostheses in a greater proportion of activities as compared to those using other device types.

Theme: Prosthetic Devices / Materials

Abstract Title: A PILOT EVALUATION OF KINEMATIC CHANGES WITH POWERED WRIST FLEXION FOR TRANSRADIAL PROSTHETIC USERS USING THE GAZE AND MOVEMENT ASSESSMENT (GAMA) METRIC

Authors: Laura Miller, Quinn Boser, Vikram Darbhe, Jacqueline Hebert, Kevin Brenner and Kristi Turner

Abstract: Wrist function is essential for correct positioning of the hand; however, few available prosthetic wrists provide powered flexion/extension. Users must compensate for this lack of function by performing compensatory body movements that may cause injuries and lead to device abandonment. Using the Gaze and Movement Assessment (GaMA) metric, we evaluated task timing, endpoint trajectories and 3D angular joint kinematics when using a 1-DOF wrist compared to a 2-DOF wrist in combination with a 1-DOF hand. We hypothesized that with the 2-DOF wrist, kinematics would be more similar to normative data and that users would perform fewer compensatory movements than when using the 1-DOF wrist.

MEC22

Theme: Clinical Research

Abstract Title: WELL-BEING AMONG INDIVIDUALS WITH UPPER LIMB AMPUTATION IS STRONGLY CORRELATED WITH BIMANUAL UPPER LIMB FUNCTION, ACTIVITY AND PARTICIPATION LEVELS, PROSTHETIC SATISFACTION AND LOWER RATES OF PAIN INTERFERENCE

Authors: Phillip Stevens, Amy Todd, Steve Mandacina, Dwiesha England and Shane Wurdeman

Abstract: A retrospective analysis of 250 individuals with upper limb amputation or limb deficiency was performed to better understand the relationships being well-being and upper extremity function, activity and participation, prosthesis satisfaction and wear times and pain interference. Well-being, as a cumulative construct of quality of life and satisfaction was found to strongly correlate with self-reported physical function in bimanual tasks, self-reported activity and participation levels, self-reported satisfaction with prostheses and reduced pain interference. By contrast, neither age, gender, time since amputation nor reported prosthesis wear times were found to correlate with well-being in this population. While causality between these closely related and overlapping constructs may prove difficult to establish, their close relationships suggest that well-being in this population may be pursued through the thoughtful provision of an appropriate prosthesis and training to enable the performance of bimanual tasks tailored to the unique activity and participation needs of the individual.

Paper Session G - Abstracts

Theme: Myoelectric Controls Algorithms

Abstract Title: TAKE-HOME TRIAL OF THE GLIDE HAND AND WRIST MYOELECTRIC CONTROL ALGORITHM: A CASE STUDY

Authors: Chris Baschuk, Rahul Kaliki, Richard Weir and Jacob Segil

Abstract: One of the most exciting developments in the field relates to the mechatronic advances which have enabled the creation of dexterous terminal devices, wrist rotators and powered elbows. However, their clinical impact has been limited by a lack of effective myoelectric control strategies. To address this challenge, we have developed a novel control strategy based on the Postural Control algorithm, which we call the Glide Controller. In this paper, we describe the first clinical fitting of the Glide system and present qualitative results on the fitting outcomes. We also discuss the implications of this control strategy from a patient and clinician perspective.

Theme: Myoelectric Controls Algorithms

Abstract Title: DEMONSTRATION OF AN OPTOGENETIC NEURONAL CONTROL INTERFACE

Authors: Arjun Fontaine, Jacob Segil, John Caldwell and Richard Weir

Abstract: Improved nerve interface approaches are sought for prosthesis control and sensory feedback as well as visceral organ study/modulation. Optical approaches that can read-in and read-out neural activity have advantages over electrode-based systems in terms of selectivity and non-invasiveness. To address limitations of existing nerve interface designs, we present an optical approach capable of reading activity from individual nerve fibers using activity-dependent calcium transients. Here we demonstrate the feasibility of using activity-dependent calcium transients to a control prosthetic hand. This work provides a proof-of-concept for an optogenetic nerve interface demonstrating as it does our ability to read-out signals at the axonal scale in real-time and apply it to a devices control.

Theme: Myoelectric Controls Algorithms

Abstract Title: ASSESSING THE FEASIBILITY OF USING SONOMYOGRAPHY FOR UPPER LIMB PROSTHESIS CONTROL

Authors: Susannah Engdahl, Samuel Acuña, Ahmed Bashatah, Ananya Dhawan, Erica King, Biswarup Mukherjee, Rahsaan Holley, Brian Monroe, György Lévay, Rahul Kaliki and Siddhartha Sikdar

Abstract: Sonomyography (SMG), or ultrasound-based sensing of muscle deformation, is an emerging modality for upper limb prosthesis control with potential to significantly improve functionality. SMG enables spatiotemporal characterization of both superficial and deep muscle activity, making it possible to distinguish the independent contributions of individual muscles during functional movements. Early offline studies have shown that SMG is capable of accurately classifying motor intent among able-bodied individuals, but it has not yet been shown whether individuals with upper limb absence can successfully use this modality for prosthesis control. This paper describes our ongoing work towards implementing SMG control for individuals with upper limb absence in offline and real-time settings. We provide strong evidence supporting the feasibility of using SMG to control upper limb prostheses.

Theme: Clinical Research

Abstract Title: THE EFFECT OF SENSORY FEEDBACK ON THE TEMPORAL ALLOCATION OF GAZE USING A SENSORIZED MYOELECTRIC PROSTHESIS

Authors: Jacqueline Hebert and Ahmed Shehata

Abstract: Myoelectric prosthesis users have altered spatial and temporal allocations of gaze, likely influenced by both control proficiency and sensory feedback. Providing task-relevant and movement feedback can improve spatial visual allocation, but temporal patterns of gaze shift have not been reported for prosthesis users with sensory feedback systems. We present data from two prosthesis users with integrated touch and kinesthetic feedback in a myoelectric prosthesis performing a functional cup movement task while tracking eye and hand movements. Despite different skill levels and task performance, both participants showed improved ability to disengage eye fixation from the object and transition to the next movement plan when provided kinesthesia and touch feedback together. Temporal allocation of gaze, specifically, the ability for the eye to disengage after interacting with objects, seemed impervious to skill level and maybe a valuable measure of the ability to trust the sensory feedback, disengage vision, and motor plan forward in a sensorized prosthesis. Eye latency measures could be a valuable marker of control skill and feedback efficacy in prosthesis users.

Poster Sessions
Tuesday (In-Person) and Wednesday (Virtual)
2:00PM-3:15PM

ID	Track	Title	Presenting Author	Location
1	Prosthetic Devices / Materials	DEVELOPMENT OF A MODULAR SIMULATED PROSTHESIS AND EVALUATION OF A COMPLIANT GRIP FORCE SENSOR	Ahmed Shehata	In Person and Virtual
2	Myoelectric Controls Algorithms	BRACHIOPLEXUS: MYOELECTRIC TRAINING SOFTWARE FOR CLINICAL AND RESEARCH APPLICATIONS	Michael Dawson	Virtual Only
3	Myoelectric Implementations	MYOKINETIC PROSTHESIS CONTROL ORIENTED ENVIRONMENTAL MAGNETIC DISTURB ANALYSIS	Valerio Ianniciello	In Person and Virtual
4	Myoelectric Implementations	THE MYOKINETIC CONTROL INTERFACE: HOW MANY MAGNETS CAN BE IMPLANTED IN AN AMPUTATED FOREARM? EVIDENCED FROM A SIMULATED ENVIRONMENT	Marta Gherardini	In Person and Virtual
5	Myoelectric Controls Algorithms	REAL-TIME PATTERN RECOGNITION OF FINGER MOVEMENTS USING REGENERATIVE PERIPHERAL NERVE INTERFACES AND IMPLANTED ELECTRODES	Alex Vaskov	In Person and Virtual
6	Myoelectric Implementations	PHANTOM HAND ACTIVATION DURING PHYSICAL TOUCH AND TARGETED TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION	Luke Osborn	In Person and Virtual
7	Clinical Research	LONG-TERM FUNCTIONAL IMPROVEMENT WITH DEXTEROUS PROSTHETIC LIMB	Erin Sutton	In Person and Virtual
8	Myoelectric Controls Algorithms	CLASSIFICATION OF TRANSIENT MYOELECTRIC SIGNALS FOR THE CONTROL OF MULTI-GRASP WRIST-HAND PROSTHESIS	Daniele D'Accolti	In Person and Virtual
9	Clinical Practice	UPPER EXTREMITY PROSTHETIC REHABILITATION: A 20 DAY PLAN OF THERAPY, EDUCATION AND COACHING.	Mark Marsico	In Person and Virtual
10	Clinical Research	CHALLENGES OF UPPER LIMB FITTING IN CANADA: A SURVEY OF UPPER LIMB PROSTHESIS USERS AND CLINICAL PROSTHETISTS IN CANADA	Holly Tetzlaff	Virtual Only
11	Myoelectric Controls Algorithms	AN ALGORITHM CALIBRATED WITH CATEGORICALLY LABELLED EMG FOR END-TO-END ESTIMATION OF CONTINUOUS HAND KINEMATICS	Alexander Olsson	In Person and Virtual
12	Clinical Research	COGNITIVE LOAD IN LEARNING TO USE A MULTI-FUNCTION HAND	Helen Lindner	In Person and Virtual
13	Prosthetic Devices / Materials	DEVELOPMENT AND CHARACTERIZATION OF A MULTIARTICULATE PEDIATRIC HAND AS A RESEARCH PLATFORM FOR FUNCTIONAL IMPROVEMENTS	Marcus Battraw	In Person and Virtual

ID	Track	Title	Presenting Author	Location
14	Prosthetic Devices / Materials	UNIVERSAL, LOW-COST TRANSRADIAL CHECK SOCKET FOR RAPIDLY VALIDATING MYOELECTRIC CONTROL	Abigail Citterman	In Person and Virtual
15	Prosthetic Devices / Materials	CASE STUDIES: FITTING PATIENTS WITH HEAVY DUTY RATCHETING MECHANICAL THUMB PROSTHESES FOR METOCARPOPHALANGEAL LEVEL AMPUTATIONS	Ben Pulver	In Person and Virtual
16	Prosthetic Devices / Materials	CASE STUDIES: FITTING PATIENTS WITH HEAVY DUTY BI-DIRECTIONAL RATCHETING THUMB RAIL PROSTHESIS FOR CARPOMETACARPAL AMPUTATIONS	Ben Pulver	In Person and Virtual
17	Myoelectric Implementations	ESTABLISHING BIONIC PROSTHETIC CONTROL IN INDIVIDUALS RECEIVING TARGETED MUSCLE REINNERVATION FOR PAIN PREVENTION	Jonathon Schofield	In Person and Virtual
18	User Experience	KEY CHARACTERISTICS OF UPPER LIMB PROSTHESIS USERS INFLUENCE PATIENT EXPERIENCE MEASURE SCORES	Linda Resnik	Virtual Only
19	Prosthetic Devices / Materials	TOUCH FEEDBACK AND CONTACT REFLEXES USING THE PSYONIC ABILITY HAND	Aadeel Akhtar	In Person and Virtual
20	Other	THE ECONOMICS OF INNOVATION IN UPPER LIMB PROSTHETICS	Karl Lindborg	In Person and Virtual
21	Myoelectric Implementations	EXPLORING THE POTENTIATION OF SENSE OF OWNERSHIP THROUGH PROPRIOCEPTION FOR A SENSORY INTERFERENCE TASK	Kathleen Campbell	In Person and Virtual
22	Myoelectric Implementations	VOICE RECOGNITION CONTROL OF A MULTI-ARTICULATING HAND FOR IMPROVED GRASP SELECTION	Todd Farrell	Virtual Only
23	Myoelectric Controls Algorithms	PROPORTIONAL ELECTROMYOGRAPHIC CONTROL OF A BIONIC ARM IN A PARTICIPANT WITH CHRONIC HEMIPARESIS, MUSCLE SPASTICITY, AND IMPAIRED RANGE OF MOTION: A CASE STUDY	Caleb Thomson	In Person and Virtual
24	Myoelectric Controls Algorithms	ALTERNATIVE MYOELECTRIC CONTROL THROUGH NEURAL SYNERGISTIC INFORMATION	Patricia Capsi-Morales	Virtual Only
25	Clinical Research	A MYOELECTRIC VIDEO GAME TRAINING PILOT STUDY: CHANGES IN CONTROL SIGNAL PROPERTIES	Carlos Martinez-Luna	Virtual Only
26	Myoelectric Controls Algorithms	A WEARABLE SONOMYOGRAPHY SYSTEM FOR PROSTHESIS CONTROL	Samuel Acuña	In Person and Virtual
27	Myoelectric Controls Algorithms	TRANSFER OF ABSTRACT CONTROL SKILLS TO PROSTHESIS USE	Sigrid Dupan	In Person and Virtual

MEC22

Theme: Prosthetic Devices / Materials

Abstract Title: DEVELOPMENT OF A MODULAR SIMULATED PROSTHESIS AND EVALUATION OF A COMPLIANT GRIP FORCE SENSOR

Authors: Eric Wells, Shealynn Carpenter, Michael Dawson, Ahmed Shehata, Jason Carey and Jacqueline Hebert

Abstract: Grip force sensory feedback is commonly stated as a desirable feature for upper-limb myoelectric prosthetics. Many techniques for non-invasive grip force feedback are being investigated. However, the choice of force sensor, feedback location, and experimental apparatus typically vary between research studies, making it challenging to compare results. A standardized device where individual parameters can be adjusted would allow researchers to evaluate the impact of each variable on results. An example of such a device is a simulated prosthesis. Simulated prosthesis devices enable non-disabled individuals to participate in myoelectric prosthesis research experiments while ensuring consistency in experimental apparatus between participants. We developed a lightweight, modular, and inexpensive simulated myoelectric prosthesis capable of delivering sensory feedback to fingertips and proximal forearm. We integrated mechanotactile feedback devices to deliver modality matched feedback to the forearm and somatotopically matched feedback to the fingertips. We compared a commercial force sensor before and after being encapsulated within a compliant material under a variety of loading conditions. The encapsulated force sensor outperformed the standard sensor in all non-ideal loading conditions by a large margin. The use of this encapsulation technique dramatically increases accuracy in sensor readings when loading conditions differ from calibration conditions. This device will help facilitate myoelectric research by providing a consistent experimental apparatus between non-disabled participants for various control and feedback-oriented studies.

MEC22

Theme: Myoelectric Control Algorithms

Abstract Title: BRACHIOPLEXUS: MYOELECTRIC TRAINING SOFTWARE FOR CLINICAL AND RESEARCH APPLICATIONS

Authors: Michael R. Dawson, Heather E. Williams, Glyn S. Murgatroyd, Jacqueline S. Hebert Patrick M. Pilarski

Abstract: Various control strategies are now available for myoelectric devices. The selection of the most appropriate strategy for an individual patient and training to improve their skills are important components to optimize user function with their myoelectric prosthesis. Existing myoelectric training software is often limited by not providing enough features to allow prosthesis users to try the multiple options for prosthetic hands, wrists, and elbows and the various control strategies used to modulate or switch between them. To address this gap, we developed an opensource training software for clinical and research applications called brachI/Oplexus that aims to provide a wider breadth of options and also be easy to use by nontechnical users. The software supports several input devices (EMG systems), output devices (robotic arms), and methods for mapping between them (conventional and machine learning controllers). A comparison was performed between brachI/Oplexus and two commercial myoelectric software programs. Results from the testing showed that brachI/Oplexus had similar or slightly improved EMG signal separation and delay when compared to the commercial software. Several research labs and hospitals are already using this software, and by releasing it open source, we hope to lower the barrier of entry and encourage other clinicians and researchers to explore this area.

MEC22

Theme: Myoelectric Control and Sensory Feedback Implementations

Abstract Title: MYOKINETIC PROSTHESIS CONTROL ORIENTED ENVIRONMENTAL MAGNETIC DISTURB ANALYSIS

Authors: Valerio Ianniciello, Marta Gherardini, Francesco Clemente and Christian Cipriani

Abstract: Several medical applications involve the use of remote magnet tracking for retrieving the position of tools instrumented with one or more magnets, when a free lineof-sight between the magnets and the tracker is not available. Our group recently proposed to implant passive magnetic markers (i.e. permanent magnets) in the forearm muscles of an amputee in order to track the displacements of those muscles during contraction. The idea is to use the retrieved information to control a hand prosthesis. We called this the myokinetic control interface. However, besides the system feasibility, how much its accuracy and precision are affected by external noise sources has not been quantified yet.

Here, through an experimental setup, we investigated the influence of different magnetic/electromagnetic interferences on the localization accuracy of three permanent magnets. The magnetic field generated by the magnets was collected both in interference-free conditions and in presence of disturbances. Localization errors achieved under different conditions, and for both raw and low-pass filtered signals, were derived. Results showed that the steel bar caused the maximum average localization error, equal to 9.8 mm and 74° in terms of position and orientation, respectively. The microwave oven caused instead the maximum localization variability, with a standard deviation of 0.21 mm and 2.2°. The low-pass filtering operation (5 Hz cut-off frequency) did not lead to significant improvement in the accuracy, resulting in an error decrease always below 7% compared to the unfiltered signals.

This work is important because it gives a quantitative measure of the disturbances encountered in everyday life which could cause the failure of those systems exploiting remote tracking.

MEC22

Theme: MYOELECTRIC CONTROL AND SENSORY FEEDBACK IMPLEMENTATIONS

Abstract Title: THE MYOKINETIC CONTROL INTERFACE: HOW MANY MAGNETS CAN BE IMPLANTED IN AN AMPUTATED FOREARM? EVIDENCED FROM A SIMULATED ENVIRONMENT

Authors: Marta Gherardini, Federico Masiero, Stefano Milici, Francesco Clemente and Christian Cipriani

Abstract: The displacement of residual muscles during voluntary contraction in a transradial amputee could be effectively exploited to control multiple degrees of freedom in a hand prosthesis. We recently introduced a new human-machine interface (the myokinetic control interface) which aims at tracking muscles contraction through implanted permanent magnets and magnetic field sensors located inside the socket. Magnetic markers (MM) tracking systems have been widely investigated in the past, especially for controlling and guiding medical tools for intra-body applications. However, specific design rules for a multiarticulate robotic hand control system have not been defined yet. Here, we studied the tracking accuracy of multiple implanted magnets by simulating different levels of trans-radial amputation using a 3D CAD model of the forearm. A magnets placing procedure was developed to position the MMs in the available muscles, following general guidelines derived in our previous study. The localizer was able to accurately track up to 9, 13 and 18 MMs, in a proximal, middle and distal representative amputation, respectively. Localization errors below ~3% the length of the trajectories travelled by the MMs during muscles contraction were achieved for all amputation levels. Not only this work answers the question: "how many magnets could be implanted in a forearm and successfully tracked with a myokinetic control approach?", but also provides interesting insights for a wide range of bioengineering applications exploiting remote tracking.

Theme: Myoelectric Control Algorithms

Abstract Title: REAL-TIME PATTERN RECOGNITION OF FINGER MOVEMENTS USING REGENERATIVE PERIPHERAL NERVE INTERFACES AND IMPLANTED ELECTRODES

Authors: Alex Vaskov, Philip Vu, Alicia Davis, Theodore Kung, Paul Cederna and Cynthia Chestek

Abstract: Commercial myoelectric control systems using surface electromyography are unable to obtain consistent control signals for finger-specific motions because the desired signals are either obscured by more superficial muscles or non-existent due to the level of amputation. Intramuscular recording techniques and Regenerative Peripheral Nerve Interfaces (RPNIs) can potentially resolve each of these issues. Two persons with transradial amputations had bipolar electrodes surgically implanted into residual musculature and RPNIs. Participants used a low latency pattern recognition system to intuitively distinguish 7 individual finger postures with 100% online success and complete a functional task requiring multiple grasps with a commercially available prosthetic hand. A classifier with the same architecture was also used to distinguish movements in a simultaneous and proportional 2 degree of freedom control scheme. Both participants used this controller in real-time to complete a virtual target matching task with success rates of 99%.

Theme: Myoelectric Control and Sensory Feedback Implementations

Abstract Title: PHANTOM HAND ACTIVATION DURING PHYSICAL TOUCH AND TARGETED TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

Authors: Luke Osborn, Courtney Moran, Erin Sutton, Adam Crego, Jonathan Forsberg, Matthew Fifer and Robert Armiger

Abstract: Restoring the sense of touch is a critical component for a closed-loop prosthetic limb. In an upper limb amputee, we explored regions on the residual limb that elicited sensory activation of the phantom hand through either physical touch or targeted transcutaneous electrical nerve stimulation (tTENS). We found that sensory sites on the residual limb responded to either physical touch or tTENS, but typically not both. Further, some regions of the phantom hand were only activated with one of the stimulation modalities, such as the thumb or wrist. Interestingly, some locations on the phantom hand could be activated with either physical touch or tTENS but at different locations on the residual limb. Our work helps highlight potential differences in perceived location of sensory feedback depending on the stimulation modality.

MEC22

Theme: Clinical Research

Abstract Title: LONG-TERM FUNCTIONAL IMPROVEMENT WITH DEXTEROUS PROSTHETIC LIMB

Authors: Erin Sutton, Luke Osborn, Courtney Moran, Michelle Nordstrom, Paul Pasquina and Robert Armiger

Abstract: Advanced myoelectric prosthetic devices aim to restore functional capability after upper limb loss. However, studies of their functional impact have been mostly limited to short -term clinical studies which rely on assessments of simple manual tasks. Here we show that a longer term study can elucidate functional improvement and quantify how and when a prosthesis is used. A participant with transhumeral amputation and an osseo-integrated interface participated first in a ten-day study of functional capability with a highly prosthesis, the Modular Prosthetic Limb (MPL). A few months later, he took the MPL home and used it daily for 12 months. He returned to the laboratory for functional assessments every two months. We measured improved scores in Assessment of Capability with Myoelectric Control, Box and Blocks Test, and NASA Task Load Index over the course of the long-term phase. Only slight improvement was documented over the short-term clinic-based phase, which suggests that longer studies may be required to assess capability with highly dexterous prosthetic limbs. Additionally, the loads experienced by the limb in the home environment were much greater than during the laboratory visits, which suggests that the functional assessments do not capture the full spectrum of loads placed on a prosthesis during activities of daily living. Through the combination of functional outcome measures, on-board data logging, and long-term studies in the home environment, we are developing the capability to assess upper limb rehabilitation progress and device appropriateness.

MEC22

Theme: Myoelectric Control Algorithms

Abstract Title: CLASSIFICATION OF TRANSIENT MYOELECTRIC SIGNALS FOR THE CONTROL OF MULTI-GRASP WRIST-HAND PROSTHESIS

Authors: Daniele D'Accolti, Andrea Mannini, Francesco Clemente, Itzel Rodriguez Martinez and Christian Cipriani

Abstract: Decoding the neurophysiological signal generated by voluntary arm movements is one of the major challenges in rehabilitation engineering. The most investigated approach for hand prosthesis control is the continuous pattern recognition of myoelectric signals. However, this is based on the assumption that repeated muscular contractions produce consistent patterns of steady-state myoelectric signals. Notably, it is the initial, transient, phase of such signals that was shown to contain a deterministic structure. Here we investigated if both wrist and hand intended movements could be decoded from the transient phase of the myoelectric signal. Twelve healthy individuals performed one of four grasps and of five wrist movements simultaneously (20 combinations). Albeit the performance in recognizing both movements simultaneously was poor, the offline data analysis showed the feasibility of implementing a sequential wrist-hand embedded controller based on the transient phase.

Theme: Clinical Practice

Abstract Title: UPPER EXTREMITY PROSTHETIC REHABILITATION: A 20 DAY PLAN OF THERAPY, EDUCATION AND COACHING.

Authors: Josef Butkus and Mark Marsico

Abstract: Despite improvements in prosthetic devices and control systems, upper extremity prosthesis rejection continues to be high. There are many issues involved in the rejection to include patient factors, speed of prosthesis delivery and quality of therapy. Quality and consistency of prosthetic training is a vital but variable part of the recovery process. Frequently therapy staff with limited experience in the prosthetic field will be the primary resource for the patient. This presentation will offer a plan of care over 20 sessions to help support clinicians offer best practices to attain the best results for their limb loss patients.

MEC22

Theme: Clinical Research

Abstract Title: CHALLENGES OF UPPER LIMB FITTING IN CANADA: A SURVEY OF UPPER LIMB PROSTHESIS USERS AND CLINICAL PROSTHETISTS IN CANADA

Authors: Holly Tetzlaff, Wendy Hill and Usha Kuruganti

Abstract: Purpose: This study aimed to survey Canadian upper limb prosthesis users and clinical prosthetists (who fit the device) to examine physical and psychosocial factors that influence the acceptance and rejection of using an upper limb prosthesis. Methods: Two separate, custom-built questionnaires were developed and sent to Canadian clinical prosthetists to participate and distribute to their upper limb patients. Results: This survey received responses from 47 clinicians, 22 prosthesis users, and one non-prosthesis user from nine provinces. Due to the small data set, responses did not show any statistical significance; however, the results highlight several important factors and the importance of patient-prosthetist relationships and rehabilitation services. Conclusion: Upper limb fitting in Canada has its challenges, and similar to other research, there are several important factors to focus on when considering acceptance of upper limb prostheses.

MEC22

Theme: Myoelectric Control Algorithms

Abstract Title: AN ALGORITHM CALIBRATED WITH CATEGORICALLY LABELLED EMG FOR END-TO-END ESTIMATION OF CONTINUOUS HAND KINEMATICS

Authors: Alexander E. Olsson, Nebojša Malešević, Anders Björkman and Christian Antfolk

Abstract: To restore limb functionality, control of a prosthetic hand should ideally be (I) proportional, i.e. produce speeds which varies in conjunction with changes in the latent intensity of muscle contractions, and (II) simultaneous, i.e. allow for both combined and independent steering of relevant kinematic degrees of freedom (DoFs). These desiderata are not straightforwardly attainable with classificatory pattern recognition applied to surface electromyography (sEMG), which only allows for the detection of a finite set of categorically encoded gestures. To alleviate such limitations, we here introduce a related approach for myocontrol which maps sEMG envelopes directly to multiple, continuously encoded DoFs, providing proportionality and simultaneity implicitly. The proposed method, termed myoelectric representation learning (MRL), is constituted by a deep learning topology and a domain-informed model training scheme. As with conventional pattern recognition, MRL operates on sEMG exclusively and is calibrated without ground truth limb kinetics, allowing for deployment with amputee users. We demonstrate the practical viability of MRL by implementing a virtual control interface driven by a setup consisting of 8 surface electrodes and capable of decoding 2 kinematic DoFs in real-time. Experiments with 10 healthy subjects, in which the interface was used to conduct tests yielding 5 numeric performance metrics, were performed to quantify the quality of myoelectric control afforded by MRL. Comparisons with the performance obtained from of a Linear Discriminant Analysis benchmark method on an identical test revealed that MRL outperforms the former in all computed measures of control efficacy

MEC22

Theme: Clinical Research

Abstract Title: COGNITIVE LOAD IN LEARNING TO USE A MULTI-FUNCTION HAND

Authors: Helen Lindner, Wendy Hill, Liselotte Hermansson and Achim Lilienthal

Abstract: Despite the promising functions of a multi-function hand, it is challenging to learn to use a hand that has up to 36 grip patterns. If it requires too much cognitive load to learn to operate a prosthetic hand, the user may eventually stop using it. Measurement of cognitive load while learning to use a bionic hand will help the therapist to adjust the training pace and help the user to achieve success.

An innovative, non-obtrusive method for measuring cognitive load is by tracking eye gaze. Gaze measures provide pupil diameters that indicate subjective task difficulty and mental effort. Three subjects wore a pair of Tobii eye-tracking glasses during control training and performed eight activities. Eye-tracking data were imported in Tobii Pro Lab software for extracting pupil diameter during the activities. Pupil diameter (normal range: 2-4mm during normal light) was used to indicate the amount of cognitive load.

Pupil diameters were below 4mm in 9 out of 23 training activities. Pupil diameters were above 4mm in all three subjects when they used precision pinch to perform the activities “stack 4 1-inch wooden blocks” and “pick up small objects”. Subject 3 had pupil diameters over 4mm in all training activities. Pupil diameters were largest when the subjects were adjusting the grip and when they had difficulties in initiating the grip.

It seems appropriate to introduce no more than four grips during the first control training session. Further study is required to determine if pupil diameters will decrease over time when adequate prosthetic training is given.

MEC22

Theme: Prosthetic Devices / Materials

Abstract Title: DEVELOPMENT AND CHARACTERIZATION OF A MULTIARTICULATE PEDIATRIC HAND AS A RESEARCH PLATFORM FOR FUNCTIONAL IMPROVEMENTS

Authors: Marcus Battraw, Peyton Young and Jonathon Schofield

Abstract: Multiarticulate upper limb prostheses for children remain sparse despite the continued advancement of mechatronic technologies that have benefited the adult population. Research in the field of upper limb prostheses is predominately adult focused, although rates of pediatric upper limb prosthesis abandonment are inflated when compared to adults. The function a prosthesis offers is a driving factor influencing whether a child will continue to wear their prosthesis. The current standard-of-care pediatric devices typically offer a single degree of freedom open/close grasping function, a stark departure from the multiple grasp configurations provided in advanced adult devices. However, as mechatronic technologies continue to advance and multiarticulate devices emerge on the clinical horizon, understanding how this technology translates effectively to the pediatric population is essential. This includes exploring grasping movements that may provide the most beneficial outcomes as well as effective ways to control the newly available dexterity. Currently, no available pediatric research platforms exist that are dexterous and boast open access to hardware and programming that allows for the investigation and provision of multi-grasp function. Here we present the development of a pediatric research platform. This dexterous pediatric-sized hand offers six degrees of freedom and programmable grasping configurations. We present our design metrics, discuss the mechanical and electrical design, and provide device performance results through benchmark testing.

MEC22

Theme: Prosthetic Devices / Materials

Abstract Title: UNIVERSAL, LOW-COST TRANSRADIAL CHECK SOCKET FOR RAPIDLY VALIDATING MYOELECTRIC CONTROL

Authors: Abigail R. Citterman, Taylor C. Hansen, Eric S. Stone, Troy N. Tully, Christopher M. Baschuk, Christopher C. Duncan and Jacob A. George

Abstract: The validation of myoelectric prosthetic control strategies for individuals experiencing upper-limb loss is hindered by the time and cost affiliated with traditional custom-fabricated sockets. Consequently, researchers often rely on virtual reality or robotic arms to validate novel control strategies, limiting end-user involvement. Here we present a multi-user, low-cost, 3D-printed transradial socket for short-term use that can be custom-fit and donned rapidly, used in conjunction with various electromyography configurations, and adapted for use with various residual limbs and terminal devices. The check socket was fabricated prior to participants' arrival, fitted by the researchers within ten minutes, and donned in under one minute. It accommodated multiple individuals and terminal devices, and its total cost of materials was under $10 USD. Across all participants, the socket did not significantly impede functional task performance or reduce the electromyography signal-to-noise ratio. The socket was comfortable enough for at least two hours of use. The development of this universal transradial check socket constitutes an important step towards increased end-user participation in advanced myoelectric prosthetic research.

MEC22

Theme: Prosthetic Devices / Materials

Abstract Title: CASE STUDIES: FITTING PATIENTS WITH HEAVY DUTY RATCHETING MECHANICAL THUMB PROSTHESES FOR METOCARPOPHALANGEAL LEVEL AMPUTATIONS

Authors: Ben Pulver, Mac Lang, Rob Dodson, Stephen Huddle, Richard Weir, Jacob Segil and Levin Sliker

Abstract: Thumb amputation presents a significant challenge for people due to the thumb's importance in creating stable functional grasps. Most thumb amputations are a result of trauma and most people with these amputations work in heavy manual labor occupations. The lack of many durable and functional prosthetic devices has caused many of these people to change or lose their jobs. This can lead to significant psychological and quality of life issues. Here we present three different case studies of patients with metacarpophalangeal (MP) joint level thumb amputations being fit with a heavy duty ratcheting mechanical thumb prosthesis, the Point Thumb. The Point Thumb features anatomical flexion at both the MP and interphalangeal (IP) joints, a virtual MP joint center for better anatomical joint alignment, heavy duty metal construction, 10 different lockable positions, and the two methods of unlocking to allow for unilateral use. The first case is a patient with multiple digit amputations who desired to return to a manual labor job. The second case is a patient with an amputation of his dominant thumb who desired to improve effectiveness performing activities of daily living (ADLs). The third case is a patient with a left thumb amputation who desired to lift heavy objects to continue his hobbies and work. This patient had previous prosthesis experience and found the

Point Thumb to be more functional than a cosmetic restoration or the TITAN Thumb. In all cases, the Point Thumb allowed patients to achieve their functional goals. These cases highlight the unique challenges present with thumb amputation and demonstrate the potential of the Point Thumb to provide users with a robust prosthetic thumb capable of handling heavy manual labor occupations.

MEC22

Theme: Prosthetic Devices / Materials

Abstract Title: CASE STUDIES: FITTING PATIENTS WITH HEAVY DUTY BI-DIRECTIONAL RATCHETING THUMB RAIL PROSTHESIS FOR CARPOMETACARPAL AMPUTATIONS

Authors: Ben Pulver, Kyle Sherk, Daniel Hill, Serena Kishek, Stephen Huddle, Richard Weir, Jacob Segil and Levin Sliker

Abstract: The loss of the thumb from the hand is a debilitating injury representing a 40% impairment to the hand. The replacement of the function of the thumb is a challenging engineering problem for prosthetic device designers due to the numerous degrees of freedom of the thumb. Most commercially available prosthetic devices for thumb amputations do not provide for adduction or rotation of the thumb. Here, we describe the design of a modular locking adduction rail for people with thumb loss proximal to the metacarpophalangeal joint. This device is compatible with the commercially available Point Thumb prosthetic thumb from Point Designs and allows users to move the prosthetic thumb from a flat hand position to an oppositional position. The design of the bi-directional adduction rail is briefly detailed. Then, two case studies are presented which detail the clinical implementation of the adduction rail into a partial hand prosthetic socket for two different patients. These are some of first trial fittings of the adduction rail system and demonstrate significant functional gains achieved with this novel device.

MEC22

Theme: Myoelectric Controls Implementations

Abstract Title: ESTABLISHING BIONIC PROSTHETIC CONTROL IN INDIVIDUALS RECEIVING TARGETED MUSCLE REINNERVATION FOR PAIN PREVENTION

Authors: Jonathon Schofield, Justin Fitzgerald, Marcus Battraw, Paul Marasco and Wilsaan Joiner

Abstract: Targeted muscle reinnervation for the prevention of neuromas and phantom pain (N-TMR) is rapidly emerging as standard surgical intervention. The efficacy of N-TMR for pain treatment and the low complexity of the nerve redirection procedure at the time of amputation have been a key aspect of its widespread adoption. However, N-TMR was not developed for prosthetic control. Unlike the original prosthetic-focused targeted muscle reinnervation surgeries, N-TMR often redirected nerves to less accessible muscles. Therefore, using surface electromyography to measure the activity of the deeper reinnervated muscles for prosthetic control is very difficult especially since muscle orientation, signal separation, and electrical crosstalk are also not considered during N-TMR surgery. To address these limitations, we investigated the feasibility of applying sonomyography, a prosthesis control technique that is capable of measuring reinnervated muscle activity across the depths of the residuum. We applied ultrasound imaging techniques paired with image processing and machine learning algorithms to classify patterns of muscle activity according to the motor intentions of participants' missing limbs. In two participants with transhumeral amputation and N-TMR surgery we demonstrated that 4-6 functionally relevant missing hand and wrist movements could be classified with 82% to nearly 100% accuracy. We suggest that like the original prosthetic-focused targeted muscle reinnervation surgeries, N-TMR provides opportunities to establish bionic interfaces with advanced prostheses. We see a significant opportunity to improve prosthetic motor outcomes for the growing number of individuals with high-level amputations that are receiving this procedure for pain prevention.

Theme: User Experience

Abstract Title: KEY CHARACTERISTICS OF UPPER LIMB PROSTHESIS USERS INFLUENCE PATIENT EXPERIENCE MEASURE SCORES

Authors: Linda Resnik, Matthew Borgia, Jacob Segil and Emily Gracyzk

Abstract: The Patient Experience Measure (PEM) was designed to assess psychosocial experiences of upper limb prosthesis users. While the PEM has been validated in a national study, differences in PEM scores based on participant characteristics have not been investigated yet. We present a secondary analysis of survey data demonstrating significant differences in PEM scores by amputation laterality (unilateral vs. bilateral), amputation level, and prosthesis type.

MEC22

Theme: Prosthetic Devices / Materials

Abstract Title: TOUCH FEEDBACK AND CONTACT REFLEXES USING THE PSYONIC ABILITY HAND

Authors: Aadeel Akhtar, Jesse Cornman, James Austin and Dhipak Bala

Abstract: The PSYONIC Ability Hand is a commercially available multiarticulated prosthetic hand with six degrees of freedom and sensorized digits. Through using contact reflexes and vibration feedback, users can grasp delicate objects without damaging them. We show results that two subjects successfully grasp hollow eggshells and fragile cups statistically significantly more often when provided with contact reflexes and touch feedback.

Theme: Other

Abstract Title: THE ECONOMICS OF INNOVATION IN UPPER LIMB PROSTHETICS

Authors: Karl Lindborg and Karl Lindborg

Abstract: Upper limb external powered prosthetic technology in recent years has experienced advancements that have produced significant increases in costs to clinics, payers, and end-users. In the United States, for new technology to be considered, the technology must fit into a coding structure called the HCPCS L-Code system. If an established L-code has not been established or the l-code does not describe the new technology, an NOS (not otherwise specified) code might be utilized. Depending on the payer source, an NOS code might not be allowed and/or the desired reimbursement of the NOS code will be reduced significantly. Usefulness of these new technological advancements must also be provided to justify its use over more conventional technology. Both usefulness and cost of a specific technology are intimately tied to the overall economic value of the prosthesis. Because the way healthcare is provided and paid for in the United States, new technology and innovation is often first introduced in the United States. This paper intends to share the author's direct experience working within private clinics, federal institutions as well as manufacturers and payers. The goal is to provide insight on the challenges faced by payers, prosthetic providers, and end-users regarding the economics of innovation in the prosthetic and orthotics industry. Researcher, therapists and MD’s and prosthetist should all benefit from this overview. Examples of the coding structure, increases in time for prosthetists to provide and maintain and justify new technology will be shared along with how payers handle innovation and payments.

MEC22

Theme: Myoelectric Controls Implementations

Abstract Title: EXPLORING THE POTENTIATION OF SENSE OF OWNERSHIP THROUGH PROPRIOCEPTION FOR A SENSORY INTERFERENCE TASK

Authors: Kathleen Campbell, Morgan Blake and Jonathon Sensinger

Abstract: A strongly perceived sense of ownership (SoO) of an amputees' device paired with agency leads to aspects of embodiment for that device. The purpose of this research was to explore the potentiation of SoO through proprioception while using a tactile feedback modality. In a sensory interference task, participants responded to vibrotactile stimulation presented to their index finger and thumb while experiencing incongruent and congruent visual feedback, with and without proprioceptive feedback. We found that participants' crossmodal congruency effect (CCE) scores for the vibrotactile feedback were higher when experiencing proprioceptive feedback that aligned with the movement of the virtual hand on the screen. Providing prosthesis users with more intuitive and useful sensory feedback may increase their perceived SoO of their device. When paired with agency, this can lead to improving their control performance and device acceptance.

Theme: Myoelectric Controls Implementations

Abstract Title: VOICE RECOGNITION CONTROL OF A MULTI-ARTICULATING HAND FOR IMPROVED GRASP SELECTION

Authors: Ben McDonald, Jen Johansson, Sam Lambrecht, Debra Latour, Brianna Rozell and Todd Farrell

Abstract: About half of upper-limb (UL) amputees do not wear a prosthesis. This is, in part, related to an inability to take full functional advantage of the prosthesis. To help address this issue, we have developed the Voice Activated Prosthesis Interface (VAPI) to allow individuals to supplement their conventional control with voice commands. Specifically, this study targeted accessing multiple grip patterns in multi-articulating hands. Data from amputee test subjects is reported showing an improvement in the time to complete tasks, more accurate grip selection, and reduced frustration with the prosthesis when using the voice recognition technology compared to standard myoelectric control.

MEC22

Theme: Myoelectric Controls Algorithms

Abstract Title: PROPORTIONAL ELECTROMYOGRAPHIC CONTROL OF A BIONIC ARM IN A PARTICIPANT WITH CHRONIC HEMIPARESIS, MUSCLE SPASTICITY, AND IMPAIRED RANGE OF MOTION: A CASE STUDY

Authors: Caleb J. Thomson and Jacob A. George

Abstract: The long-term goal of this research is to restore intuitive and proportional motor control to stroke patients with an assistive exoskeleton. Stroke is the leading cause of disability in the United States, with 80% of stroke-related disability coming in the form of hemiparesis, presented as weakness or paresis on half of the body. Current electromyographic-(EMG)-controlled assistive exoskeletons do not allow for fine force regulation. That is, current control strategies provide only binary, all-or-nothing, control based on a linear threshold of EMG activity. In this case study with one hemiparetic stroke patient, we show that state-of-the-art EMG control algorithms can provide proportional control of a bionic arm despite weak and spastic muscle activity. The participant completed a virtual target-touching exercise with an EMG-controlled bionic arm by attempting to grasp (close) or extend (open) their hand. The participant completed the task under two conditions, with EMG from their paretic arm and with EMG from their healthy, contralateral arm. For grasping, there was no statistical difference in task performance for the paretic and healthy arms, but there was a significant decrease in the EMG signal-to-noise ratio for the paretic arm. For extension, there was a significant decrease in both task performance and EMG signal-to-noise ratio for the paretic arm. Despite these differences, the participant was still able to complete the target-touching task with the paretic arm. These preliminary results show it is possible, for at least some patients, to provide proportional control of assistive devices using weak and spastic EMG. Importantly, information regulating fine force output is still present in EMG despite a visually immobile arm due to hemiparesis. Future work will validate these findings with additional stroke patients with varying presentations of hemiparesis and move into controlling upper-limb exoskeletons.

Theme: Myoelectric Controls Algorithms

Abstract Title: ALTERNATIVE MYOELECTRIC CONTROL THROUGH NEURAL SYNERGISTIC INFORMATION

Authors: Patricia Capsi-Morales, Deren Barsakcioglu, Manuel G. Catalano, Giorgio Grioli, Antonio Bicchi and Dario Farina

Abstract: This work combines for the first time structural and computational synergies defined by neuronal information. The main idea is to investigate the existence of motor neuron synergies and their potential as sources for myoelectric control. First, we developed a new version of the soft hand with 2 degrees of actuation (DoA) for prosthetic applications. Then, we used HD-sEMG to study the behaviour of motor units in different manipulation tasks and to identify motor modules or neural synergies. Based on this dimensionality reduction in both the mechanical prosthetic design and the neural control, we propose a method to map the neural information into prosthesis control. With this approach, we first show that neural synergies have greater dimensionality than classic muscle synergies. This property and a greater degree of independence determine the possibility of a natural, robust and simultaneous control of several DoA by neural synergies. The proposed method can be implemented into an available framework of online decomposition (i.e. online extraction of motor units) in order to create a platform to study different myoelectric control methods and compare their performance in a virtual environment, and in the real-time control of the SoftHand Pro-2. The creation of this platform permits further developments on the existence of modules in upper-limb motor control, the relation between different synergistic levels and its use for assistive and rehabilitative robotics with different type of patients.

Theme: Clinical Research

Abstract Title: A MYOELECTRIC VIDEO GAME TRAINING PILOT STUDY: CHANGES IN CONTROL SIGNAL PROPERTIES

Authors: Carlos Martinez-Luna; Craig Kelly; Brianna Rozell; Samuel Lambrecht; Andrew Horowitz; Todd Farrell

Abstract: A myoelectric video game controller was developed which maps two-site upper-limb prosthesis control signals to mouse/keyboard commands via wireless Bluetooth. This Myo-Electric Gaming Interface (MEGI) is targeted for exercising and training clinically relevant control signal properties and strategies. This study evaluated the effects of video game training on myoelectric control signal properties over a six-week period. A racing game was used to training proportional twosite myoelectric control using a differential control strategy and co-contractions. Signal amplitude maxima and distribution of control speeds were observed across the training of three pilot able-bodied subjects.

MEC22

Theme: Myoelectric Controls Algorithms

Abstract Title: A WEARABLE SONOMYOGRAPHY SYSTEM FOR PROSTHESIS CONTROL

Authors: Samuel Acuña, Susannah Engdahl, Ahmed Bashatah, Paul Otto, Rahul Kaliki and Siddhartha Sikdar

Abstract: Sonomyography (SMG) is a promising alternative to electromyography (EMG) for extracting control signals from functional muscle activity in real time. SMG uses ultrasound imaging to non-invasively record superficial and deep muscle activity, making it possible to differentiate the independent contributions of individual muscles during functional movements. Previous challenges surrounding the miniaturization of ultrasound instrumentation have prevented exploration of SMG as a feasible modality for prosthesis control. In this paper, we describe our work developing a 4-channel wearable ultrasound system capable of tracking in vivo muscle interfaces using frequency-modulated continuous wave imaging.

Theme: Myoelectric Controls Algorithms

Abstract Title: TRANSFER OF ABSTRACT CONTROL SKILLS TO PROSTHESIS USE

Authors: Sigrid Dupan, Simon Stuttaford, Kianoush Nazarpour and Matthew Dyson

Abstract: Computer interface tasks have shown that motor learning based control schemes enable multi-grip myoelectric control with only two electrodes. However, it is unclear if this control transfers to prosthesis use. Here, we test if training abstract control with delayed feedback transfers to prosthetic control in a 7-session experiment. Two participants completed five 1-hour training sessions in between a pre- and post-test. The abstract decoding scheme ensured participants had access to five grips (power, tripod, point, lateral, and hand open), and the prosthetic tests included a grip matching task, the modified box and blocks task, and a pick and place test. Both participants increased their grip matching score, reaching a classification accuracy of 93.33% and 98.33%. They also increased the amount of blocks they relocated in the modified box and blocks test, completed the pick and place test faster, lowered the amount of objects they dropped, and increased the accuracy of the grips they selected during the pick and place test. These results show that a motor-based training strategy of abstract control transfers to prosthetic use, enabling five grips with only two electrodes.